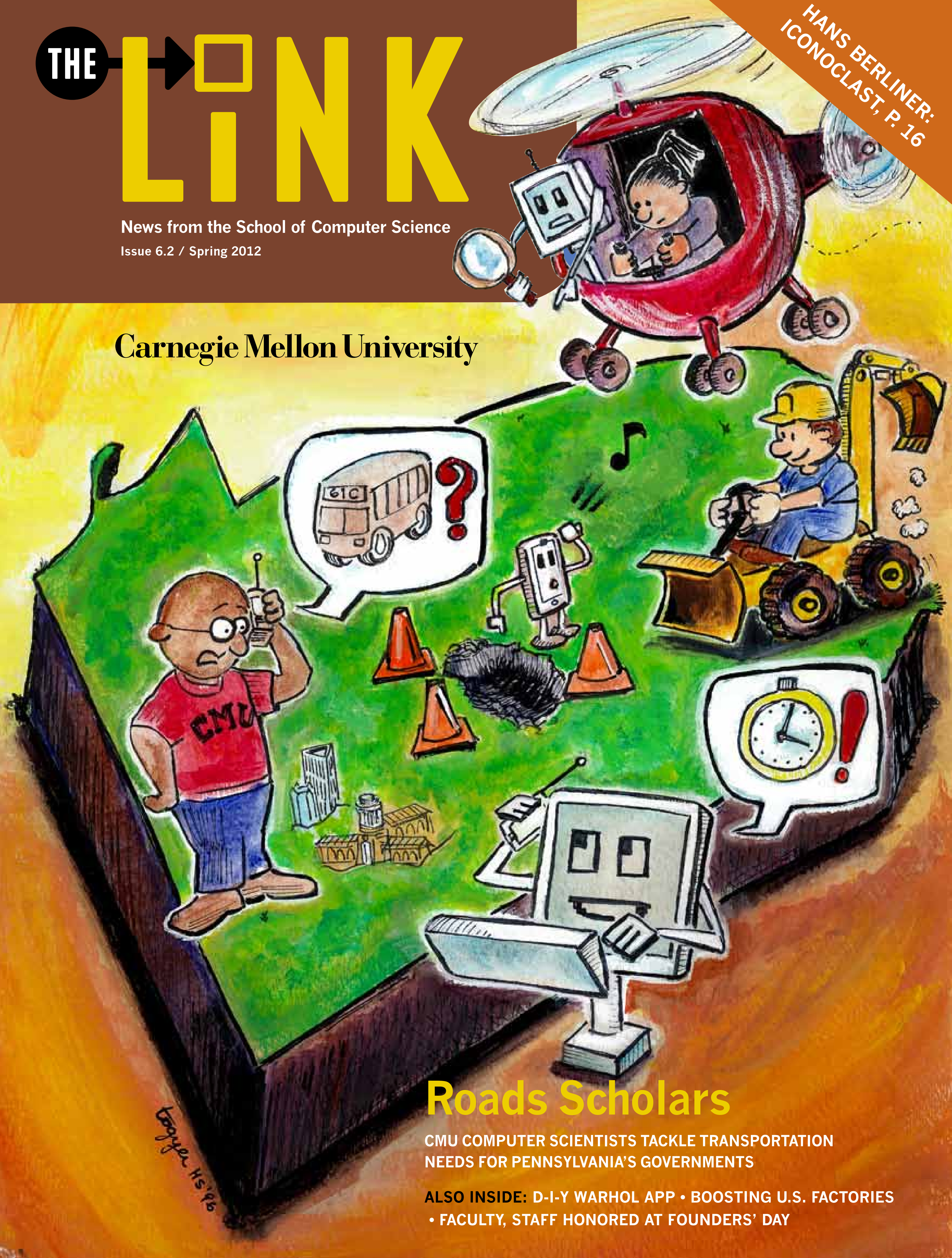
THE LiNK

News from the School of Computer Science

Issue 6.2 / Spring 2012

HANS BERLINER: ICONOCLAST, P. 16

Carnegie Mellon University



Roads Scholars

CMU COMPUTER SCIENTISTS TACKLE TRANSPORTATION NEEDS FOR PENNSYLVANIA'S GOVERNMENTS

ALSO INSIDE: D-I-Y WARHOL APP • BOOSTING U.S. FACTORIES • FACULTY, STAFF HONORED AT FOUNDERS' DAY

THE LINK

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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CALENDAR OF EVENTS

All events to be held on the Carnegie Mellon University campus in Pittsburgh, unless otherwise noted. Dates and locations are subject to change without notice. Visit calendar.cs.cmu.edu for a complete and current listing of events.

April 18
Dedication Ceremony: The Robert Mehrabian Collaborative Innovation Center
11 a.m., Collaborative Innovation Center

April 19–21
Spring Carnival 2012
Campus-wide

April 19
Olympus Spring Carnival Show & Tell
4:30–6 p.m., McConomy Auditorium, University Center

April 20
18th Annual Mobot Races
Noon, Wean Hall, fifth-floor entrance

National Robotics Engineering Week Lecture
Howie Choset: "Robotics 101, 102, 103…"
2 p.m., Rashid Auditorium, 4401 Gates and Hillman Centers

April 25
Carnegie Mellon Celebration of Education
4:30 p.m., University Center

April 28
SCS Day 2012
Rashid Auditorium, 4401 Gates and Hillman Centers

Carnegie Mellon Qatar Science Educators Workshop
8:30 a.m.–3 p.m.
Laboratory Room 2196, Lecture Hall 1213, West Walkway, Qatar Campus

May 1
Carnegie Mellon Qatar Meeting of the Minds research symposium
4–6 p.m.
East & West Walkways, Qatar Campus

May 1
CMUQ Research Forum
Noon–4 p.m.
Lecture Hall 1202 and West Green Spine, Qatar Campus

May 4
Last day of classes, spring term

May 7–15
Final exams

May 7
Carnegie Mellon Qatar: Graduation Ceremony

May 8
CSD faculty meeting
3:30 p.m., 3305 Newell-Simon Hall

May 17–18
CSD "Black Friday"
6115 Gates and Hillman Centers

May 19
SCS Honors Ceremony
10 a.m., Rashid Auditorium, 4401 Gates and Hillman Centers

May 20
Commencement 2012
11 a.m., Gesling Stadium

SCS Diploma Ceremony
1 p.m., Carnegie Music Hall, 4400 Forbes Ave.

May 21
Summer term begins

May 22–24
Robotics Professional Education Course
National Robotics Engineering Center, Lawrenceville

May 28
Memorial Day: No classes

June 6
CSD faculty meeting
3:30 p.m., 6115 Gates and Hillman Centers

June 15–16
ACM A.M. Turing Centenary Celebration
Palace Hotel, San Francisco, Calif.

June 23
SCS/ECE Boston Alumni Networking Luncheon

July 1–19
Carnegie Mellon Qatar: Summer College Preview Program

July 4
Independence Day: No classes

July 7
SCS/ECE San Diego Alumni Networking Cruise

July 8
SCS/ECE Seattle Alumni Networking Cruise

July 14
SCS/ECE San Francisco Bay Area Alumni Reception
San Francisco Museum of Modern Art

Aug. 14
Summer term ends

Aug. 27
Fall term begins

Sept. 3
Labor Day: No classes

Sept. 10
Fall term add/drop deadline

Oct. 4–7
Cèilidh: Homecoming and Family Weekend
Campus-wide

Oct. 19
Mid-semester break: No classes

Nov. 21–23
Thanksgiving holiday: No classes

Nov. 25
Andrew Carnegie born 1835, Dunfermline, Scotland (died 1919)

Dec. 7
Last day of classes, fall term

Dec. 10–18
Final exams

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FLIGHT OF THE SEABIRDS PHOTO VIA FLICKR AT WWW.FLICKR.COM/ SEABIRD; USED UNDER CREATIVE COMMONS LICENSE

Issue 6.2 / Spring 2012

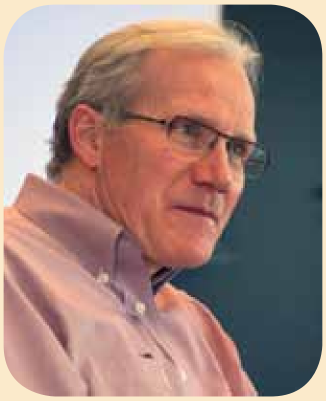
On the Cover:
Software and apps developed at SCS are finding potholes, providing transit information and tracking trouble spots. Our colorful cover depicts some of the technology being deployed across Pennsylvania to help local governments and other agencies.

The illustration is by Link Managing Editor Jason Togyer (HS'96), who also provides a monthly cartoon for the readers of Popular Communications magazine, and who painted a portrait of radio pioneer Reginald Fessenden for the cover of that publication's December issue.

Jennifer Bails' story, "Roads Scholars," begins on Page 10.

P.S.: Welcome to our largest-ever issue of The Link! We hope you'll drop us a comment at thelink@cs.cmu.edu, or via postal mail at The Link Magazine, SCS Office of the Dean, Carnegie Mellon University, 5000 Forbes Ave., Pittsburgh, PA 15213 USA. You can also call 412-268-8721.

Randal E. Bryant



Randal E. Bryant

The growing reach of SCS

It's been an exciting year for us, with our educational and research efforts proceeding apace. Last year, we were excited to have 3,481 applicants to our undergraduate program, breaking the record of 3,237 applicants set in the dot-com-boom days of 2001. This year, the record has been shattered again—4,200(!) applicants aspired to be part of our entering class of 140 students next fall.

There's no doubt that computer science is a hot field among prospective college students these days, and Carnegie Mellon University has built a strong reputation as the "go-to" place for computer science education.

Realistically, though, a program such as ours can only supply a small fraction of the world's need for trained computer scientists. In addition to our traditional role of educating the "best of the best" at our campuses, we recently embarked on a cooperative program with the Kenya Informational and Communication Board to address the need for qualified software developers around the world.

Along with our partners in Kenya, we're creating a certification exam that we hope will be able to determine whether an applicant for an entry-level job in software development has the skills in program development, testing and debugging that companies want and need.

However, unlike existing software certification exams, which simply test whether someone can answer a selection of multiple-choice questions reflecting factual knowledge, ours will be an authentic exam, meaning that the candidate will have to demonstrate his or her skills in an actual software development environment. That might seem like a fairly standard way of testing—after all, we wouldn't trust the piloting of an airplane to someone who had only answered a set of multiple-choice questions about the principles of aviation—but it has never been attempted on a large scale for software development.

In recognition that software development is becoming a driving force in the world economy, the World Bank is funding the project. We've held meetings with companies involved in global software development, especially in the U.S. and India, and the response has been very enthusiastic.

I traveled to Kenya earlier this year with part of the project team for a kick-off event. (That's me in the third photo, along with Phil Miller, the SCS project scientist in charge of this effort.) In addition to meeting with educators, government officials and journalists, we had a chance to visit the Rift Valley to see the zebras and giraffes. You can learn more about the project at http://news.cs.cmu.edu/article.php?a=2914, and you'll hopefully be reading about it in The Link and other CMU publications in the months and years ahead.

Randy Bryant

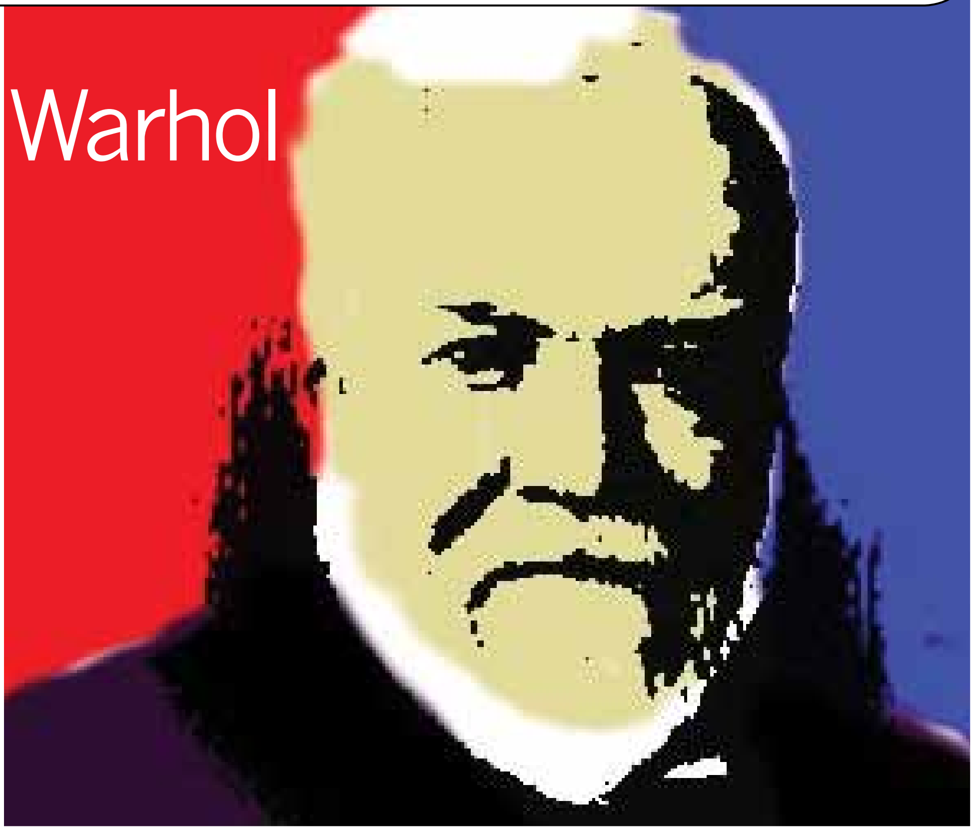
Randal E. Bryant
Dean and University Professor
School of Computer Science
Carnegie Mellon University

SUBMITTED PHOTOS COURTESY RANDY BRYANT

Above: Phil Miller, SCS project scientist, and SCS Dean Randy Bryant on a tour of Hell's Gate National Park in Kenya, northwest of Nairobi.

Do-it-Yourself Warhol

CMU project brings pop artist's silk-screening process into the app age



MARY LYNN MACK ILLUSTRATION

Carnegie Mellon University's founder, Andrew Carnegie, gets the Warhol treatment from an app developed by students in the Professional Software Engineering Program.

> By Mary Lynn Mack

Ever since Pittsburgh's Andy Warhol Museum opened in 1994, visitors have had the opportunity to learn hands-on the silk-screening process popularized by Warhol as a means for creating fine art. But emulating Warhol's art without the correct equipment (and the training to use it) isn't easy, and the hands-on experience offered by the museum is limited to those who either lived in or were visiting the Pittsburgh area.

All that has changed since three students in Carnegie Mellon University's Professional Software Engineering Program, or PSEP, collaborated with the museum to create Warhol D.I.Y. Pop, an app for the iPhone, iPod Touch and iPad designed to digitally simulate the silk-screening process while educating users about the artist, his art and his influence on popular culture. More than 70,000 people have downloaded it so far.

"Audiences have really liked the product," says Rick Armstrong, communications manager for The Andy Warhol Museum. "And while it isn't really for us to say, many have commented that Warhol himself would have liked the product and been behind it. After all, from Mylar to film and even silk-screening, he was always looking for new ways to create, produce and re-create art quickly."

The project was part of what professor Matthew Bass describes as the PSEP's "learn by doing" approach. Students routinely work on real-world projects that are sponsored by external clients, balancing the needs of an organization within the limitations of the selected technology, resources and budget.

"Most graduates don't get this kind of experience until they have spent years on the job," Bass says.

Arguably one of CMU's most famous alumni and Pittsburgh's best-known artists, Warhol in the 1960s popularized the use in fine art of a particular screen-printing process called serigraphy. In serigraphy, an image or design is superimposed on a very fine mesh screen. The image can then be transferred to paper or canvas by spreading paint or ink through the screen. Warhol used serigraphy to create his famous portraits of celebrities such as Marilyn Monroe and Elvis Presley.

To learn as much as they could about the process, master's students Ramkumar Nagarajan (CS'10), Kothanda Ramaswamy (CS'10) and Dinesh Ramadoss (CS'10) first spent time working with the museum's curator of education and interpretation, Tresa Varner, to learn how to crop, expose and paint images using woven screens, paint and squeegees.

"Once we had an understanding of how the process worked manually, we could begin working on how to re-create that process digitally," Nagarajan says.

In PSEP projects, Bass says, students must balance completing their task with demands of their other courses. The Warhol project, which spanned two semesters, took the team approximately 24 weeks to go from client proposal to delivered product. Ramadoss estimates the team spent more than 30 hours per week developing the app.

The team worked together on all aspects of the project, taking turns leading various parts. "We wanted everyone to have the opportunity to learn as much as possible," Ramaswamy says.

In the finished app, users start their digital silkscreen print by snapping a picture with the device's built-in camera or selecting a photo from their image library to use as the starting image. In order to prepare the image to be painted and silkscreened, a "positive" must be created of the cropped image. (Warhol, who died 25 years ago this February, would have sent his cropped images to a photographic studio to create a black-and-white image on transparent film, also known as a film positive.)

Next, colors are added to areas of the image (vibrant colors help create a more Warhol-like masterpiece) by brushing a stylus or finger across the white areas of the positive. Users can follow closely along the lines of their image positive or just apply random blocks of color. (Warhol often did both.) The final step of the process is pulling the digital squeegee across the image using a contrasting color (dark colors are usually a good choice) to create the black areas of the image positive. After the screening is done, users can make adjustments to their art, save it or share it.

Warhol D.I.Y. Pop was the first paid app from The Warhol and despite what Armstrong calls a "very modest" marketing budget, was an instant success. It was Apple's top-selling app on the day of its July 11 release, was featured in *The Wall Street Journal* and was named a "Pick of the Week" by the tech blog Gizmodo. >>>

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Perhaps some of the users were inspired by Warhol's prediction that "in the future everybody will be world-famous for 15 minutes." As part of the product introduction promotion, users had the opportunity to extend their 15 minutes. The museum selected images created by users with the app to share on their website and in the museum's Entrance Gallery. Each image—a few on display included an orange and black cat, a brightly colored portrait of a young woman and a two-toned image of a man spinning records—was shown for 15 days before retiring.

While the scope of the original project did not allow for development for other platforms besides Apple products, Bass says another group of PSEP students has begun a follow-on project to develop a similar solution for the Android.

Bass says the PSEP program is always looking for new external clients with which to partner on projects. "This is a project we couldn't have done without CMU's involvement, because we wouldn't have had the budget to develop the creative product from scratch," Armstrong says.

Editor's Note: For the Warhol D.I.Y. Pop app, visit www.warhol.org/connect/mobile/

Turning Up the Volume

Hear Me, a project spearheaded by CMU's CREATE Lab, is telling the stories of Pittsburgh's kids and young adults

> **By Tom Imerito with Jason Togyer**

Monessen is a struggling former steel mill town in Pennsylvania's "Mon Valley," about 25 miles south of Pittsburgh. Today, in a classroom at Monessen Middle School, eighth-grade English teacher Mary Dodaro can see that Alisha, one of her students, is distressed.

Dodaro asks 14-year-old Alisha to think about what's bothering her, collect her thoughts and organize them into a story. She does. And when Alisha is satisfied with the results, she approaches a microphone set up in the school auditorium, and begins to read.

She talks about living in a homeless shelter for six months. She talks about being put up for adoption—and how she worried that she would be torn away from her brother, JJ, in the process. She talks about finally being adopted by her grandmother, and she vows to stay close to JJ for the rest of her life.

As Alisha is reading her story, other Monessen Middle School students are waiting in the hallway. They can't believe that adults actually care what they have to say. Some of them read their stories aloud and then ask if they can get back in line and do it again.

The microphone is connected to a computer that's recording every story these kids tell. When Alisha and her fellow students are done, Dodaro edits the audio files and sends them to SLB Radio Productions, a non-profit located at the Children's Museum of Pittsburgh on the city's North Side.

There, Carnegie Mellon alumnus Larry Berger (E'83), executive director of SLB, and his colleagues turn the files into stories for the Hear Me project, a program developed by the CREATE Lab at the Robotics Institute. Berger will use Alisha's tale, and the others, on his weekly live radio program, "The Saturday Light Brigade," which airs on CMU's WRCT-FM (88.3) and five other stations in two states, plus Pittsburgh's cable TV system. The stories also will be uploaded to the Hear-Me.net website.

Hear Me is one of 14 community enhancement projects designed by the CREATE Lab, whose name stands for Community Robotics, Education and Technology Empowerment. The project got its impetus in 2008 when the Grable Foundation, a Pittsburgh philanthropy that funds projects for children's education, asked a group of community leaders to develop programs that would improve the quality of life for youth in the region.

In response, Illah Nourbakhsh, CMU assistant professor of robotics and founder of the CREATE Lab, proposed Hear Me, an Internet-based repository of images, writings, recordings and videos that express the thoughts of children ages 3 to 17 in four topic areas—community, education, health and wellness, and environment.

Although the electronics and software that power Hear Me aren't revolutionary, Nourbakhsh and others say the way that Hear Me uses and deploys that technology is unusual, because it makes powerful audio (and soon, video) storytelling highly accessible and personal to kids and adults.


SUBMITTED PHOTO

Retired Steelers wide receiver Hines Ward meets a group of students from the Clairton, Pa., school district during a meeting arranged by the CREATE Lab's Hear Me project.

Besides the website, children's stories are also being distributed in tin cans inspired by "tin can telephones." With the cans, students can record their own stories, personalize the wrappers and then trade them with other schools to hear other students' stories. They become audio "pen pals," or what the Hear Me project calls "can pals."

Another innovative distribution method for stories collected by Hear Me is an SLB-developed StoryBox device, a somewhat more polished variation on the "tin cans" that allows stories to be hung on the wall (like art) in public locations. On New Year's Eve 2010, for instance, StoryBox units were deployed at Pittsburgh's First Night celebrations. Visitors who pressed buttons on the front of the StoryBox units could hear local students express their hopes and wishes for the coming year.

After being advertised on billboards throughout the Pittsburgh area last summer, the Hear Me >>>

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project caught the attention of a producer from USA Network, a cable TV division of NBCUniversal. The producer was in town to work with former Pittsburgh Steelers wide receiver Hines Ward on a documentary series called "Characters Unite." Ward, who was born in Korea to mixed-race parents, was planning to tell the story of his childhood struggle to assimilate himself into an American town.

Inspired by the billboards, the producer went to the Hear-Me.net website, then called Heide Waldbaum, who was director of Hear Me at the time, and arranged for Ward to spend time in a high-school classroom in Clairton, another cash-strapped Mon Valley steel mill town. There, Ward sat down to talk with Carlton Dennis, a 17-year-old junior born in Trinidad whose life story and struggles were remarkably similar to the football player's. Ward and Dennis talked about ways that they learned to stay positive in the face of prejudice and discrimination. The resulting story was captured both by USA Network and Hear Me, and aired nationwide on USA in February.

About 60 students in Clairton as well as the nearby McKeesport, Steel Valley and Woodland Hills school districts are currently participating in Hear Me's newest initiative, Hear Me 101. Students learned the fundamentals of video production at a workshop hosted by Pittsburgh Filmmakers on Feb. 4 and are now creating videos focusing on changes they want to see in their communities. The videos will debut later this year on Hear Me's website.

Meanwhile, Carlton's story is now part of the Hear Me archive, along with the stories of Styles, 4, who loves monkeys because of their mutual affinity for bananas; and Marie, 17, who nearly dropped out of school before feeling remorseful, and became more determined than ever to graduate; and Savion, 8, who misses his cousin, who was shot to death while walking down the street.

Since its inception, Hear Me has worked with more than 3,000 kids in dozens of regional school districts, community organizations and child care centers. Jessica Kaminsky and Jessica Pachuta are now running Hear Me at the CREATE Lab, and are working to create a network of trained storytellers and story collectors—Hear Me Kids and Hear Me Teachers as well as Hear Me Schools and Hear Me Organizations—to encourage children and young adults to tell their stories.

"We assume that kids have adults at home who are interested in what they have to say, and that's not necessarily the case," says Dodaro, who is on leave this semester to work as educator-in-residence at the Consortium for Public Education in McKeesport, Pa. "For some of them, I think Hear Me is a validation of their opinions, their insights, their viewpoints."

Editor's Note: For more information, go to Hear-Me.net. This story was reported by Tom Imerito and written by Link Editor Jason Togyer. Tom Imerito is a Pittsburgh-based freelance writer. Email him at tom@science-communications.net.

Building a Better Robot Workforce

Creating jobs for humans might just start with improving the jobs done by technology

By Meghan Holohan

A student scurries over to an orange robotic arm hovering above a checkerboard. He studies the arm, and then adjusts it slightly before returning to his computer. The arm slowly moves across the board, stops suddenly and projects a green-hued mirror image of the board.

As David Bourne watches the student calibrating the robot, he explains that the robot is estimating where a certain physical object should be placed as part of an assembly, and is using the projection to show the worker who is doing the assembling the exact location. Robots are excellent at measuring—if a worker needs to put together a machine, a robot can tell her where to place a clamp, down to the smallest increment. A human can do this, too, but it takes a lot more time and work. Bourne is interested in creating robots that collaborate well with humans in a manufacturing setting.

"How do we tell the robot what to do, and then how do we get the robot to tell the human what to do?" says Bourne, a principal system scientist at the Robotics Institute at Carnegie Mellon University.

He designs robots to custom-produce small runs of items in quantities as cheaply and effectively as those done in large-scale manufacturing. He envisions an era of "pop-up" manufacturing, where companies can quickly erect a plant where robots and humans work together anywhere they might be needed. His goal is to see manufacturing jobs that have moved to other countries return to the United States.

In June 2011, President Obama visited Carnegie Mellon's National Robotics Engineering Center, or NREC, to launch his Advanced Manufacturing Partnership, a collaborative effort between U.S. companies and universities, including CMU, that's trying to create more high-tech manufacturing jobs in the United States.

"Innovations led by your professors and your students have created more than 300 companies and 9,000 jobs over the past 15 years—companies like Carnegie Robotics," Obama said. "But more important than the ideas that you've incubated are what those ideas have become: They've become products made right here in America and, in many cases, sold all over the world. And that's

Matt Mason

in our blood. That's who we are. We are inventors, and we are makers, and we are doers."

Bourne isn't the only professor in the School of Computer Science working on projects that might transform manufacturing in the United States.

In his office on the Pittsburgh campus, Matt Mason places a robotic hand, once used to assemble Sony Walkmans, on a conference table. It's a metal ball with six protruding "arms," each of which could handle one task; one could pick up a tray, for example, while another could >>>

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stretch a rubber band. The ball rotated so that each hand could accomplish its goal, but these hands weren't very smart, Mason says. They could only perform a very limited set of tasks.

In the past several decades, researchers have attempted to build more versatile, "smarter" hands by focusing on creating robotic appendages that function like human hands. But human hands are very complex—there are 15 joints in the fingers alone—so creating a robot hand that works like a human one is a huge undertaking.

Mason—director of the Robotics Institute and professor of computer science and robotics—wants to make a hand that's simply designed, much like those "grabber" extensions used to pull items off of high shelves in stores, but that's also able to function with the sensitivity of a human hand. Mason demonstrates, using one of those "grabbers" and a bowl of mini candy bars. He picks up a candy bar with the grabber, but the candy bar is on its side. Mason wants it to be flat. A person can tell without looking if the item is flat in her fingers, but a robotic hand does not know if the bar is flat, on its side or askew. By adding sensors and cameras, and then using machine-learning techniques to analyze the visual and tactile data it receives, the hand can pick up the pieces and hold them correctly.

The ability to understand the orientation of a physical object is important for assembly operations, when a worker needs to grab parts from bins and put them into place on a circuit board or frame. A worker can stick her hand into a bin of parts, select the correct one and hold it the proper way without even looking. But robots lack that sensitivity and dexterity. It's one reason why assembly of electronic gear such as cell phones is done in developing nations, where human labor is inexpensive and plentiful.

Mason has a prototype of a more sophisticated robotic hand that he demonstrates by picking up dry-erase markers. With just three slender metal fingers, it looks like the "claw machine"—familiar from arcades and family restaurants—that was depicted in the movie "Toy Story." (In fact, Mason says that the researchers have been testing the hand with a bunch of the toy aliens from "Toy Story.") But unlike the "claw," it requires no human intervention to correctly orient the dry-erase markers. A robot like this prototype—working alongside humans—could one day help bring some electronics assembly jobs back to the United States. Robot and human employees together could make U.S. manufacturing less expensive than overseas factories that rely solely on human work.

While Mason and Bourne are developing prototypes, John Bares, former director of NREC, is trying to turn prototypes into products. Bares is a co-founder of Carnegie Robotics. He says that professors often develop prototypes and want to commercialize them, but do not have the time or capabilities to do so, so they ship their prototype to an outside company for commercialization. Carnegie Robotics is perfectly positioned to be that other entity, he says. The company conducts its product engineering and development in Pittsburgh and tries to keep robotics fabrication in the region by encouraging local companies to bid.

But Bares adds that he thinks more broadly, and he's happy if he can keep the work in the United States. "We have consultants and [subcontractors] across the United States, but 75 percent of the work is done [in Pittsburgh]," he says.

While he can't divulge many details, Bares notes that Carnegie Robotics is working on several defense-related projects to build robots that detect IEDs in warzones. And the company is developing sensor technology such as its new product called "EyesOn," which will allow remote operators of robots to develop "situational awareness"—an understanding of the whole environment and surroundings in any area in which they're operating a robot.

Tony Stentz, current director of NREC, calls the relationship between the center and Carnegie Robotics "quite beneficial. At NREC, for instance, we do a lot of work that is sponsored by third parties, and they are quite often very interested in generating a robot and actually using that robot to solve some particular problem. If we don't have the full story—from the basic development to making multiple copies—they might not be interested in dealing with us."

Reversing a decades-long decline in U.S. manufacturing jobs won't happen overnight. But nationwide partnerships like the AMP—and local partnerships like those of CMU with Carnegie Robotics and its network of subcontractors—provides some hope that such a goal can be achieved.

Meghan Holohan is a Pittsburgh-based freelance writer whose work has appeared in PittMed, MentalFloss.com and Salon.

From Ideas into Reality

Investors are backing high-tech concepts that got their start as part of SCS' Project Olympus

> By Meghan Holohan

When new MBA student Jeff Mullen arrived at Carnegie Mellon University's Tepper School of Business in 2007, he had several ideas floating through his head—ideas that he hoped some day might be transformed into a business.

One day, as he shopped online, Mullen began thinking about the problems with online security. Hackers regularly gain access to customers' personal information, including credit card numbers used in previous transactions. But what if the credit card number changed after each transaction? Old account numbers would be useless. The time was right, Mullen decided, for a smarter credit card.

Soon, Mullen and several Tepper school colleagues were trying out prototypes in their spare time. But if their idea was going to be more than a school project, they needed material, office space and start-up money.

At the same time, Lenore Blum, Distinguished Career Professor of Computer Science at the School of Computer Science, had received a $400,000 grant from Pittsburgh's Heinz Endowments to create Project Olympus, a business incubator for CMU students and faculty. "Olympus was created to help students start thinking about companies and developing their ideas in the regional economy," Blum says.

She talked to Mullen about his and other fledgling entrepreneurs' need for office space. Mullen and fellow Olympus student Brian Wirtz (TPR'09) found a place for rent on Henry Street right off Craig; Mullen's new company—christened Dynamics Inc.—commandeered the loft (now nicknamed "charm").

Dynamics worked out of the loft for six months before moving to offices on Craig Street and later into its own building. Mullen (E'00, TPR'09) lured the head of emerging technologies from

STEPHEN BRASHEAR PHOTO COURTESY THE DEMO CONFERENCE, USED UNDER CREATIVE COMMONS LICENSE. WWW.STEPHENBRASHEAR.COM.

COURTESY DYNAMICS INC.

Jeff Mullen, CEO of Dynamics Inc., says Project Olympus deserves a healthy share of the credit for his company's success. Dynamics Inc. is developing a credit card with shifting security features to foil identity thieves and counterfeiters. An early prototype is shown at right.

Visa and gave his colleagues an ultimatum: Dynamics is a business, and if you can't treat it that way, move on. His dedication and vision has paid off. Upon graduation from CMU and Olympus, Dynamics received $5.7 million in first-round funding led by Adams Capital Management in Pittsburgh.

In June 2011, Dynamics received $35 million in second-round, or "Series B," financing from a group of investors led by Bain Capital Ventures of Boston—the largest Series B funding ever awarded to a Pittsburgh-based startup. The Pittsburgh Technology Council named Dynamics the technology innovator of the year for 2011.

Mullen, the company's CEO, says Olympus deserves a healthy share of the credit. "They gave us a home when we needed a home and they gave us support," he says. "They do serve as an insulator, they do help protect you and you are allowed to make mistakes."

As Dynamics has evolved, Mullen's original concept has morphed from a card with changing digits to a card with a programmable magnetic strip. This allows Dynamics to offer several different credit cards—the multicard, for example, lets users access all their accounts on one credit card by pushing a button. The redemption card enables consumers to use either their credit card or redeem their rewards points, also by pressing a button. The programmable card is so popular that Citibank, the world's largest issuer of credit and charge cards, has announced that it's developing a new generation of cards based on Dynamics' technology.

Dynamics is one of the biggest Olympus success stories, but it isn't the only one. Olympus helped Marek Michalowski (CS'09) secure a licensing agreement for his BeatBots—consumers can now purchase a less expensive version of his interactive robot, Keepon, called MyKeepon. Olympus was the supporter and champion of reCAPTCHA, a system for preventing spam and digitizing textbooks developed by Luis von Ahn, the university's A. Nico Habermann associate professor of computer science; in 2009, the technology was acquired by Google.

Since 2007, 44 student PROBEs, or "project-oriented business explorations," and 16 faculty PROBEs have resulted in new companies. Four of those companies received venture capital funding and eight earned small business innovation research funds.

BlackLotus is another student PROBE that recently made a splash when it won venture capital funding. After garnering attention at the Rice University Business Plan competition, the company received $2.5 million in first-round or "Series A" funding from DFJ Mercury, a Houston-based venture capital company, and Silverton Partners, an Austin-based venture capital group.

BlackLotus' principals Rodrigo Carvalho, Lukas Bouvrie and Francisco Uribe created a web-based application that allows retailers to compare pricing among online competitors, giving businesses the ability to change prices or analyze performance with ease. Unlike Dynamics, which stayed in Pittsburgh, BlackLotus has relocated to Texas.

Uribe was a graduate student in the eBusiness master's program in the School of Computer Science when the trio met and had launched several companies in his native Chile. When he met Carvalho and Bouvrie, fellow MBA students at Tepper, they were hoping to become entrepreneurs, too, but didn't know what kind of company to start. Uribe rattled off idea after idea until the two decided he was a perfect partner. Then they turned their attention toward ecommerce.

Blum is still looking for a dedicated funding stream to keep Project Olympus' doors open. Every day, she says, students and faculty arrive at the office, looking for help and hoping that they'll start the next big company.

Mullen, for one, hopes Blum gets the support she seeks. Project Olympus, he says, "allowed us to become what we wanted to become."

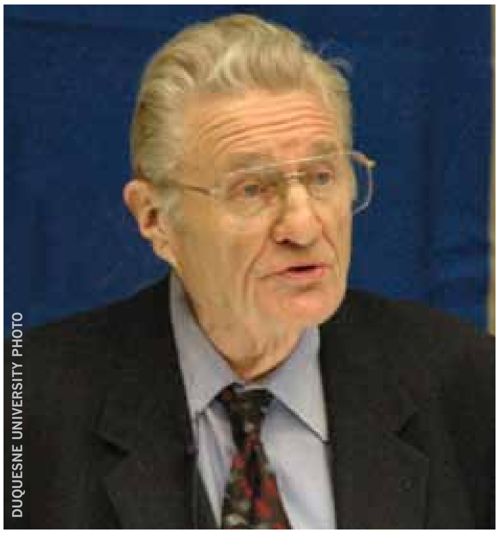
LTI spinoff nets $500K NSF grant

> By Byron Spice

The National Science Foundation has awarded a $500,000 Phase II Small Business Innovation Research grant to Safaba Translation Solutions LLC, a company spun out of the Language Technologies Institute.

Safaba will use the SBIR funding to gear up for its upcoming product launch. Founded by Alon Lavie, LTI associate research professor, and Robert Olszewski (CS'94,'01), the company is developing a software-as-a-service model that enables small- and medium-size language translation firms to take advantage of automated translation programs. Safaba software will help those companies expand their services and increase their productivity by incorporating machine translation tools that are customized to their needs.

Safaba has received support from Project Olympus and CMU's Center for Technology Transfer and Enterprise Creation, both part of CMU's Greenlighting Startups initiative, as well as from the Idea Foundry and the Greater Oakland Keystone Innovation Zone.


DUQUESNE UNIVERSITY PHOTO

For a man who described himself as a "thick-skulled, occasionally dumb-witted" kid from the East Side of New York City, Tom Murrin did more than OK.

Murrin, who died Jan. 30 at age 82, rose through the ranks of the former Westinghouse Electric Corp. from the factory floor to the executive suite before taking a top position in the U.S. Department of Commerce. He later served as dean of Duquesne University's business school. A graduate of Fordham University, where he played football for the legendary coach Vince Lombardi, Murrin first came to Pittsburgh in 1951 to take a job as a manufacturing and materials engineer in a Westinghouse plant. He remained with the company for the next 36 years.

In the late 1970s, Murrin was worried that the United States was losing its technological and industrial leadership. In interviews and editorials, he argued that American colleges were not producing enough graduates interested in science and technology careers. As president of Westinghouse's Public Systems division, Murrin was in a position to do something about that. In 1979, Murrin joined with CMU's Raj Reddy and Angel Jordan to found the Robotics Institute, arranging a $3 million research grant to the university from Westinghouse Electric, then a $7.4 billion Pittsburgh-based conglomerate.

Dedicated in December 1980, the Robotics Institute initially focused on such industrial projects as Westinghouse's automated "Factory of the Future," which was installed at the corporation's turbine plant in Winston-Salem, N.C., in 1981. But RI research quickly moved into many other areas, including computer vision, autonomous navigation, healthcare and medicine, and remote exploration and sensing of dangerous and distant environments, including space travel. "We owe a debt of gratitude to Mr. Murrin for his vision and for his leadership," says Matt Mason, current director of the Robotics Institute. "He had a profound effect on this university and on the growth of robotics in general."

Murrin, an admirer of "total quality management" and a staunch advocate for Japanese industrial principles for improving quality and productivity, was widely believed to be a candidate to become Westinghouse's next chairman. But when he was passed over for promotion (Murrin believed his blunt, no-nonsense style had offended too many people over the years), he retired. President George H.W. Bush named him deputy secretary of commerce in 1989.

Two years later, Murrin became dean of Duquesne University's business school, where he also taught a graduate-level course called "Executive Insights into Contemporary Global Issues." Former Duquesne President John Murray told the Pittsburgh Post-Gazette that Murrin's classes were always crowded: "These were unique in America. Nobody was offering these classes because they were really Murrin 101." Murrin stepped down as dean in 2000, but continued to teach until 2006, when he retired from DU as a distinguished service professor.

A fellow of the National Academy of Engineering and a former chairman of Duquesne's board of trustees as well as Fordham's board of directors, Murrin is survived by his wife of 60 years, Dee; seven daughters; one son; 12 grandchildren and a great-grandson.

—Jason Togyer (HS'96)

Carlos

Carlos Guestrin is Finmeccanica associate professor of machine learning and computer science and co-directs the Sense, Learn, and Act (Select) Lab with Geoff Gordon. A graduate of the Polytechnic School of the University of São Paulo, Brazil, Guestrin earned his Ph.D. in computer science from Stanford University in 2003.

His main research interest is in developing efficient algorithms and methods for designing, analyzing and controlling complex real-world systems.

A member of the DARPA Information Sciences and Technology advisory group, Guestrin was the recipient of an NSF CAREER Award and the Presidential Early Career Award for Scientists and Engineers and was twice awarded an IBM Faculty Fellowship. In 2008, Popular Science magazine named Guestrin to its "Brilliant 10" list of the "brightest researchers" in the United States.

He spoke to Link Managing Editor Jason Togyer.

Your undergraduate degree is in mechanical engineering. How did you wind up in computer science?

I wanted to do something that seemed "futuristic"—even though the word "futuristic" now seems retro—so one day I went into my professor's office and said, "I'm really interested in robotics." He said, "Well, I work in computer vision, maybe you want to work with me?" I did wind up working on a robot, and it was a very interesting experience, but at the end of my undergraduate years, I decided I wanted to do something more theoretical for my Ph.D., and artificial intelligence was very interesting to me.

Why not stay in robotics?

I switched to AI because I was building things that demonstrated "intelligence," but I didn't understand where it was coming from. AI also allows me to examine the frameworks of why we perceive intelligence.

What is "perceived intelligence"?

In even the simplest things, such as a spam filter, we might say "Oh, that was smart how it figured out that message was spam." But the

Guestrin

JOHN BARNA PHOTO

Carlos Guestrin

way an algorithm does spam filtering is not the way that a human being would do spam filtering. Although we may work with mathematical models, not rule-based systems, our challenge is to make the right mathematical models—the right assumptions.

What led to your work on the Cascades algorithm?

When I finished my Ph.D., I had built a theoretical foundation for working on AI, but I was missing an application domain. I went to Intel for a year with a group that was deploying sensors in a forest to understand a microclimate. In such a situation, you want to capture the data—say, water contamination—as close to the source as possible, but sensors are expensive. I decided there must be some way to balance the cost of collecting the information with the need for putting out enough sensors. We developed what we thought was a really nice theory that evolved into the Cascades algorithm, which you can use for a variety of applications where you might need to develop a sensor network.

How did you apply the Cascades algorithm to analyzing the spread of news?

A blog is kind of like a sensor. It's trying to capture a story as early as possible. Two students working with me, Andreas Krause and Jure Leskovec, said, "Where else would the Cascades algorithm be useful?" One of them said, "Well, I have this blog data to analyze, maybe it would be useful there." We applied the same algorithm to the spread of information on the web, and it turns out that the way stories spread in the blogosphere is very much like contaminates spreading through water. We were able to identify the top 100 blogs that report news stories as early as possible.

What's the practical application of knowing that?

Information overload is perhaps one of the most important sensing problems of the coming decade. Ten years ago, we were already talking about the explosion of the Internet. Who knows where we're going to be 10 years from now? And this is not just an issue with the Web—it's an issue with the scientific process, with the political process. It's a very pressing challenge, and computer science is able to deal with this kind of problem.

Can't we just use search engines to filter information?

Right now, when you look for information on the Web, you do a keyword search. You might get 10 results and if you're not happy with them, you change your keywords. It's an iterative process. What are better ways to look for information besides changing your queries? Then there's another problem—I may not know which sources to trust. I'm just overwhelmed from every direction.

How can computer science address those problems?

Think about the economic crisis triggered by the collapse of AIG, and about the health care debate. There must be a way those two stories are connected, right? One way to find those connections is to get an article on each topic and find the shortest path connecting the two. If you do that now, you'll find strong but superficial connections—it's like a stream of consciousness, or a conspiracy theory generator. What we're trying to do is give you more comprehensive information about how a connection comes about.

We're also working on a way to use networks to determine the trustworthiness of sources. There are many ways to give feedback on what to trust, and what not to trust. You can look at who else cites a particular source, for instance.

Another area of our research is ways of suggesting new sources of information. We often have a very biased perspective—we may go to the same websites all the time, or maybe we always read the same influential researchers' papers. We don't really have a good way to learn which things we don't know about. Maybe our model can suggest other people or websites we might be interested in.

By analyzing those things you're interested in, I can get a very good sense of your biases and build a model and push you to discover things that you don't know. There's a real opportunity to help all of us be exposed to multiple points of view.

You create paintings, sculptures and collages. Why are you so passionate about art?

Artists typically use their art for emotional expression, and there's definitely a joy to having a creative outlet—although my work here is also a creative outlet. CMU has a lot of very interesting art-related activities, both in our department and across departments, and I think it's really nice to be in an environment such as this. Recently I taught a class with Osman Khan, a visiting art professor, and that was very exciting for me. When I was deciding what to do career-wise, I considered pursuing a career in art—and now I say, if CS doesn't work out, I can always fall back on art!

Roads Scholars

Cash-strapped governments throughout Pennsylvania are getting concrete help with their problems from Carnegie Mellon University

> By Jennifer Bails

Anyone who has lived in Pittsburgh knows that a better name for late winter might be "pothole season," as craters big enough to swallow a Smart car or two rip open the city's roadways.

But it was a bump in the road—quite literally—that Takeo Kanade didn't expect when he first came to Carnegie Mellon three decades ago from the milder climes of Japan. The problem has continued to vex Kanade over the years, his frustration intensifying with each new pothole encounter.

"One day I was driving down Fifth Avenue, and there was a huge pothole I didn't expect and couldn't avoid," says Kanade, the U.A. and Helen Whitaker University professor of robotics and computer science at CMU. "Those are very bad experiences."

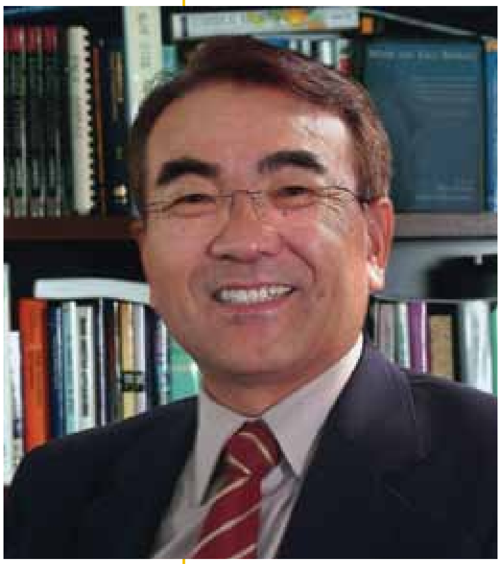
Pittsburgh motorists are all-too-familiar with these "very bad experiences," but with perpetually tight city finances, overworked road crews can't always keep up with repairs or even locate all the potholes in order to fix them. That's why Kanade recently set out to use his computer vision expertise to help develop a system—called the Road Damage Assessment System, or RODAS—to detect and report potholes.

When people think about universities helping local governments and public agencies, state-run schools and land-grant colleges often come to mind—not private institutions like Carnegie Mellon. But a number of projects such as RODAS are under way at the university—many from the School of Computer Science—to help cash-strapped municipalities meet the challenges they face in an era of shrinking budgets.

It's a trend rooted in Carnegie Mellon's historical emphasis on tackling real-world problems, says Jennifer Meccariello Layman, CMU's assistant director of government relations, and it has its roots both in Andrew Carnegie's drive "to do real and permanent good in the world" and in the work of the original Mellon Institute of Industrial Research.

"Even though Carnegie Mellon has evolved into a really elite institution, the faculty and students and staff look at Pittsburgh and western Pennsylvania as this wonderful test bed for their research," Layman says. "You can build all the computer models you want and write all the algorithms you want, but if your technology doesn't work when you go out into the real world, what's the point?"

It doesn't get much more real than being stranded in sub-zero temperatures after blowing out a tire on a nasty pothole. >>>



SUBMITTED PHOTO

Takeo Kanade

SUBMITTED PHOTO

Robert Strauss

SUBMITTED PHOTO

The Road Damage and Assessment System, or RODAS, allows anyone to snap a photo of a pothole and automatically pinpoint its image on a map, creating a public repository of road conditions.

DAMON TAYLOR PHOTO VIA FLICKR, USED UNDER CREATIVE COMMONS LICENSE. WWW.FLICKR.COM/OCEAN_OF_STARS

RODAS allows anyone to upload a photo of a pothole and then pinpoints the image on an online map, creating a public repository of road conditions. It was developed together with Robert Strauss, professor of economics and public policy in CMU's Heinz College, and former graduate students Todd Eichel and Veronica Acha-Alvarez.

Last winter, more than 600 potholes were reported across Pittsburgh using RODAS. And there is interest from the Pennsylvania Association of Boroughs in deploying the system in some of the 958 municipalities the organization represents statewide. "We have to protect the investment we've made in our public infrastructure, and most local governments don't have the resources to invest in a solution like this," says E.J. Knittel, the association's director of events and information services.

Other SCS technologies are also putting the power to improve community services right in the hands of the community itself. This past summer, researchers at the Rehabilitation Engineering Research Center on Accessible Public Transportation, or RERC-APT, a collaboration between CMU and the University at Buffalo, released a free mobile crowd-sourcing app that allows Port Authority of Allegheny County riders to signal the location and occupancy levels of their buses.

Called Tiramisu—Italian for "pick me up"—the system counts on people to activate the application on their smart phone when they get on the bus, record how full the vehicle is and press a button allowing the phone to share a GPS trace with a server that relays the information to other riders at later stops.

In this way, transit users can get real-time reports about whether their bus will arrive on time and find out if there will be space on board—information of special concern to riders with disabilities, according to Robotics Institute senior systems scientist Aaron Steinfeld, co-director of RERC-APT, who leads the Tiramisu team with SCS colleagues Anthony Tomasic and John Zimmerman.

"Where's the bus? Am I going to get to sit down?—these are questions everybody asks, but it is really valuable information if you need space for a wheelchair or it takes you extra time to reach your stop," Steinfeld says.

While most Port Authority buses have a GPS box used to notify riders about upcoming stops, these units aren't connected to a backend server that would be needed to remotely monitor bus location. To engineer its own real-time tracking system would cost the Port Authority millions of dollars it doesn't have; the agency's projected $64 million budget deficit for the coming fiscal year could yet lead to deep service cuts.

"Real-time information is something that's been in demand, but unfortunately, it's something we can't afford to offer," Port Authority spokeswoman Heather Pharo says. "We're extremely fortunate to have an institution like Carnegie Mellon that looks at problems and recognizes our limitations and then comes up with an ingenious workaround solution."

More than 18,000 recordings were made in the first few months after the release of Tiramisu in July, and the value of the app (available for iPhone and Android platforms) will grow in proportion to the number of users. If no one is using Tiramisu on a particular bus, the system predicts arrival times using historical data or the bus schedule.

"What we really hope is that it becomes self-sustaining in terms of the data being generated," Steinfeld says. "But we don't know yet what the critical mass is for the system. It's one of the very interesting research questions that Tiramisu lets us explore."

Plans are also in the works to study the motivations that compel riders to help each other by using Tiramisu and to explore whether the system could be of commercial value in other locales.

"Pittsburgh is very much a city where people want to help each other, so we are a little nervous about going to other cities," Steinfeld says. "But we are hoping this desire to want to help your fellow rider is something that transcends location."

Tiramisu, Pharo says, has improved the transit experience for Port Authority customers and has the potential to boost ridership—outcomes that make the hard work both fun and worthwhile to the researchers.

"Any research that you do that is out there in the real world is more enjoyable than research that is hidden away in the lab," Steinfeld says. "And this is the best kind of research. It's not just research in the wild—it's actually being used in the wild."

Data from Tiramisu are being put to even further use to help power Let's Go, a spoken dialogue system developed by CMU Language Technologies Institute principal systems scientist Maxine Eskenazi and her colleagues that provides automated schedule and route information to Port Authority riders.

The Port Authority operates bus, light rail, incline and paratransit services for nearly 230,000 daily riders. The agency customarily staffed its phone lines on weekdays through early evening and for limited weekend hours. But after the operators ended their shifts, no one was available to answer transit questions.

That changed six years ago, when Eskenazi and SCS associate professor Alan Black launched the Let's Go system. Funded by the National Science Foundation, the project was designed to improve the response to spoken queries from elderly and non-native speakers, two groups that often have difficulty using voice-activated software.

Since going live in 2005, the system (trained to understand "yinz" and other idiosyncrasies of "Pittsburghese") answered more than 175,000 calls. It ran year-round under the watch of Eskenazi's team, filling in after-hours, when Port Authority's customer-service representatives weren't available. Coverage eventually expanded from eight transit lines to 60, representing more than half of the agency's routes, and 80 percent

Tiramisu, an iPhone application developed at CMU, employs crowdsourcing to let riders of Pittsburgh's Port Authority transit system know when the next bus is scheduled to arrive.

of the time, callers received the information they needed in an average of 1.5 minutes—success rates comparable to the best commercial systems.

"We have saved the Port Authority hundreds of thousands of dollars and provided a valuable service to the City of Pittsburgh," Eskenazi says. "It's nice to get out of the ivory tower and actually see people using what you are doing and be able to give back. And in the end, having applied research often pushes the research itself uphill."

More than 150 scientific papers reference Let's Go, and Eskenazi and her colleagues have amassed an invaluable real-world dataset to study spoken dialogue architectures and ways to improve speech interfaces.

And a new, highly robust version of their system—called Let's Go Now—was just launched using Tiramisu data to provide scheduling information for all of the county's bus lines. It operates 24 hours per day through a direct phone line (412-268-3526) independent of the Port Authority.

"It's a system that is going to be of much more help to the callers," Eskenazi says. "In many cases, they will be getting crowd-sourcing and historical information that is better than what we were giving them before. And they will have an even higher success rate in getting what they need."

"It's nice to get out of the ivory tower and actually see people using what you are doing and be able to give back. And in the end, having applied research often pushes the research itself uphill."

Maxine Eskenazi, principal systems scientist, LTI

Howard Stern, formerly the city's chief information officer, worked closely with Eskenazi and other SCS scientists while overseeing technology initiatives for the city.

"Running the city's technology shop for me was more than just keeping the email system running and fixing a printer when it broke," says Stern, who was recently named associate dean of academic administration at Pittsburgh's Carlow University. "It was imperative to be imaginative and push the limits of technology, and CMU helped us push those limits by working on applications…to make city government more efficient."

For instance, CMU computer scientists have helped to create digital maps of crime activity and school guard routes in the city. They have advised government officials in making critical decisions about issues such as citywide Wi-Fi. They are helping to create robotic devices that could help detect leaks in pressurized water lines, developing smarter traffic lights to alleviate downtown congestion, and much more.

"When you can't raise taxes, how do you raise efficiencies?" asks Doug Shields, who represented the neighborhoods near the CMU campus on Pittsburgh City Council from 2004 to 2012. "Increased efficiencies come from technology applications, and many of those are available from some of the most brilliant people in the world right on our doorstep."

One source of funding for some of these applications, including Tiramisu, has been the Traffic21 initiative, launched three years ago by Carnegie Mellon with support from the Hillman Foundation. >>>

Pittsburgh philanthropist Henry Hillman has provided the university with $1.25 million for this endeavor to create “intelligent transportation systems” for the region, such as traffic signals that adapt to congestion patterns and automated sensors to diagnose bridge problems. Many Traffic21 (as in 21st century) projects are being undertaken with community organizations such as the Pittsburgh Cultural Trust and the Allegheny Conference on Community Development.

Through investment in the development of “smart traffic” technologies, CMU is helping the region access state and federal funds to deploy these systems, according to Traffic21 director Richard Stafford, distinguished service professor of public policy in the Heinz College. He says marketable solutions could also create new commercial spin-offs and improve the local economy.

“By partnering with the community,” Stafford says, “we have created a test-bed for pilots of our technologies and created the opportunity to then make our research and development more relevant.”

Several SCS faculty have received Traffic21 seed money for their work, such as Robotics Institute research professor Stephen Smith, who is piloting a system to improve scheduling for the Port Authority’s paratransit service. Likewise, Robotics Institute senior project scientist Christoph Mertz is developing technologies to save money on road maintenance for the Pennsylvania Department of Transportation (PennDOT) and other public works agencies. Among Mertz’s projects is an automated system that would use vehicle-mounted cameras to generate a 3D surface map of the pavement and help spot potholes.

Thanks to the early success of Traffic21, Carnegie Mellon is on track to receive a $3.5 million grant to become a federal research center in smart transportation. There’s also a proposal to create—in conjunction with the University of Pennsylvania’s School of Engineering and Applied Science—a new Consortium for Technologies for Safe and Efficient Transportation. The consortium would develop transportation applications that could influence everything from vehicle and road safety to the analysis of traffic flow, as well as launch a workforce development program.

“We have the CMU world interested in problem-solving and the real world that has problems,” Stafford says. “Not all our faculty are interested in these kind of problems, and not everyone with a problem is interested in CMU intervening. At Traffic21, we are looking for the intersection between both worlds—that’s the space that’s really important.”

It’s a lesson that Kanade learned the hard way when the RODAS team went live with its pothole detector system last winter; there was some pushback from public works officials concerned about the negative image of their department being projected by the public reckoning of the city’s road problems.

Pittsburgh City Councilman Bill Peduto says local government needs to be more open to technological solutions such as RODAS. Peduto, whose East End council district includes the universities of Oakland, cites the example of CMU President Jared Cohon’s offer two years ago after “Snowmaggedon”—when more than two feet of snow fell overnight in Pittsburgh, shutting down CMU and other campuses—to harness university resources to develop a state-of-the-art snow removal route system for the city.

That offer wasn’t accepted, said Peduto, who has frequently been at odds with his council colleagues and the city administration. “There wasn’t a willingness to break from the pen, paper and clipboard (methods) that our guys use now,” said Peduto, who argues that governmental agencies sometimes suffer from a cultural mindset of “this is just the way things are done.”

Researchers who are proposing technology solutions for local government agencies soon find out that a big part of their work involves communicating with elected officials, says Acha-Alvarez (Hnz’11), who worked on the RODAS project. Some of her greatest rewards, she says, come from figuring out how to do that part of her job better.

“I am a computer engineer, but I am also very interested in public policy,” she says. “From my soul as a technologist, I know that technologies are just a tool. We are the people responsible to show the rest of the community why these technologies are important for them. If I’m not doing a good job at that, then it’s my problem.

Says Acha-Alvarez: “I am still trying to figure out how to knock on the door and convince people: ‘This is for you. I don’t need this, but it will be useful for you.’”

Jennifer Bails is a Pittsburgh-based freelance writer who covers science and technology. Visit her website at jenniferbails.com.

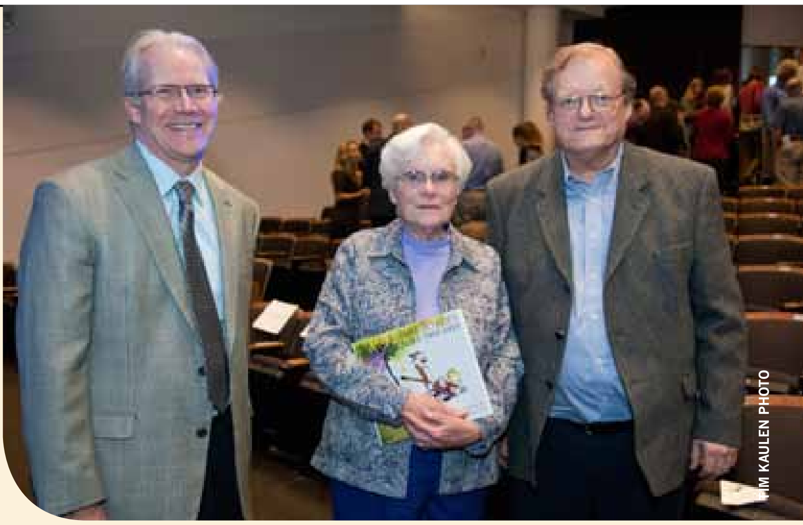
“I am still trying to figure out how to knock on the door and convince people: ‘This is for you. I don’t need this, but it will be useful for you.’”

Veronica Acha-Alvarez (Hnz’11)

MELISSA STOEBE PHOTO

Faculty, staff honored at first SCS Founders' Day

New celebration recognizes more than half-century of research, education launched by Newell, Simon, Perlis



SCS Dean Randy Bryant with Noel Newell, wife of the late Allen Newell (TPR'57), and Peter Simon, son of the late Herb Simon.

TIM KAULEN PHOTO

More than one-third of all funded research at Carnegie Mellon University is conducted at the School of Computer Science, reported Dean Randy Bryant in his "State of the School" address Feb. 23.

Of that total, about 25 percent comes through CMU's National Robotics Engineering Center in Lawrenceville, Bryant said.

Between 1995 and 2011, research income at SCS grew from $26.4 million to $73.9 million, Bryant told an audience in the Hillman Center's Rashid Auditorium during SCS's first-annual Founders' Day celebration. (Adjusted for inflation, the change represents an increase of more than 90 percent.) During that same period, total income in the SCS budget increased from approximately $39.1 million to $105.6 million.

Undergraduate education is not the same financial factor in the SCS budget as is research, Bryant said, but he noted it's definitely a "labor of love" and that the quality of SCS undergraduates is impressive. Average SAT scores of current first-year computer science students are 769 math, 729 reading comprehension and 724 writing. The scores are "totally scary," Bryant joked, adding that "obviously, none of us would have gotten in."

TIM KAULEN PHOTO

Indra Szegedy, administrative coordinator in HCII, shared an award for "rookie of the year" with Mark Penney of SCS.

The new SCS Founders' Day celebration honors Allen Newell, Herbert Simon and Alan Perlis. Perlis (S'43) served as first head of CMU's Computer Science Department and received the A.M. Turing Award in 1966 for his influence on computer programming techniques and compiler design, while Newell (TPR'57) and Simon were longtime CMU faculty members who received the Turing Award in 1975 for their contributions to artificial intelligence and cognitive science. "The influence of those three people really defines who we are today," Bryant said.

Bryant credited Satya—Mahadev Satyanarayanan (CS'79,'83), CMU's Carnegie Group Professor of Computer Science—with the idea of SCS Founders' Day. Newell's wife, Noel, and Simon's son, Peter, were present during the ceremony, along with CMU trustee and former computer science professor Eric Cooper. Cooper, founder of FORE Systems Inc., and his wife, Naomi Weisberg Siegel, recently endowed new Cooper-Siegel professorships for career development. Eric Paulos of the Human-Computer Interaction Institute in SCS and Richard Pell, assistant professor of art in the College of Fine Arts, are the inaugural recipients.

Following Bryant's address, David Kosbie (CS'90) was honored with the Herbert A. Simon Award for Teaching Excellence, which is selected by a vote of the SCS student body. Bryant pointed out that on the "Rate My Professors" website, Kosbie scores almost a 5 out of 5 in every category except "Easiness," which in CMU terms is "a good thing." Kosbie, an assistant teaching professor in the Computer Science Department, thanked Mark Stehlik, outgoing SCS assistant dean for undergraduate education, for providing daily leadership, guidance and support.

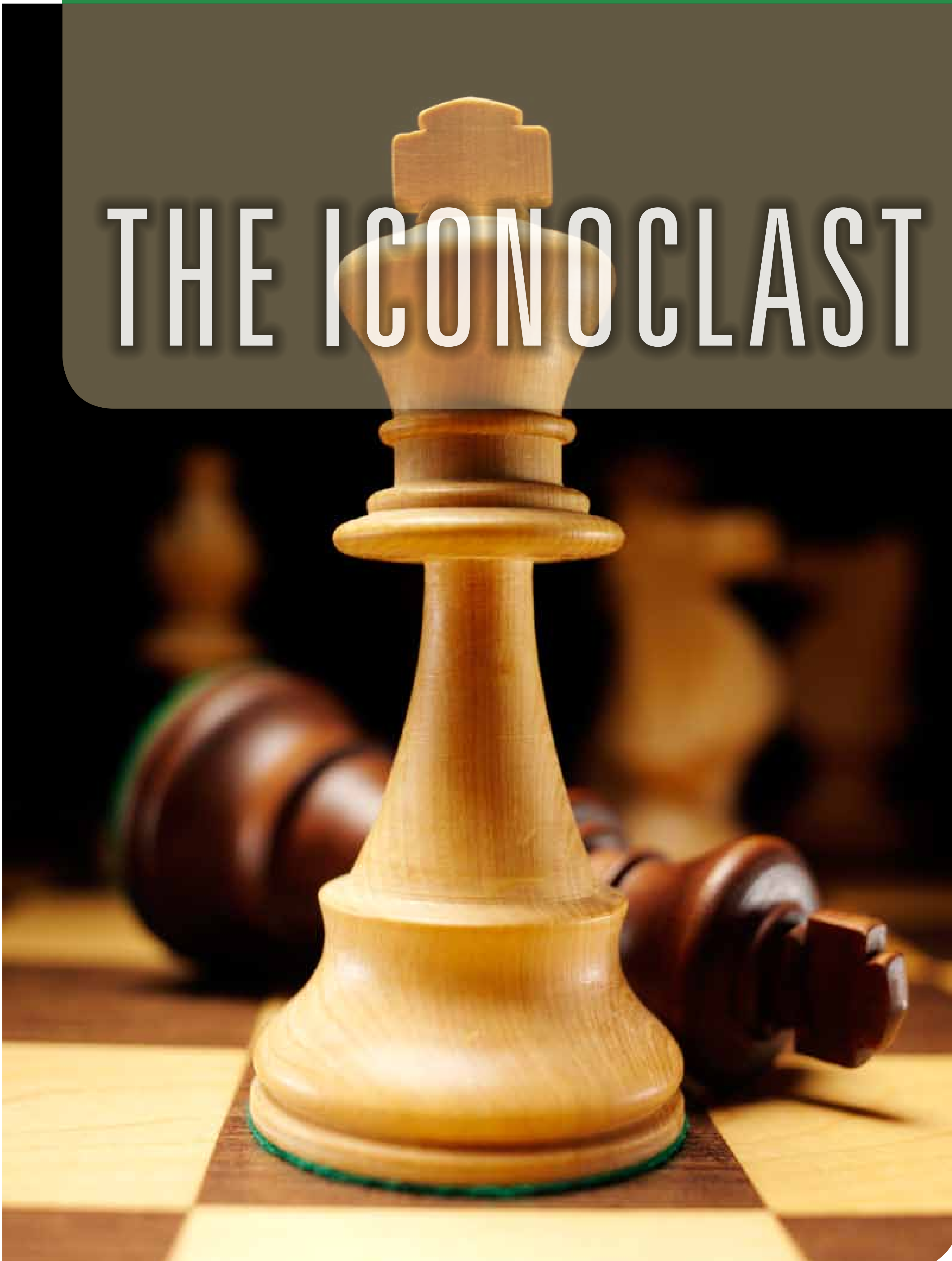
Honored with SCS's Allen Newell Award for Research Excellence were Eric Nyberg (HS'92), professor in the Language Technologies Institute; Teruko Mitamura, research professor in LTI; Nico Schlaefer (CS'12), who recently received his Ph.D. in language technologies, and Hideki Shima, a Ph.D. student in LTI. The award was presented for their work on question-answering systems, including their significant contributions to IBM's Watson, which defeated two human "Jeopardy!" champions in a special nationally televised tournament in 2011.

Honored with staff recognition awards were:

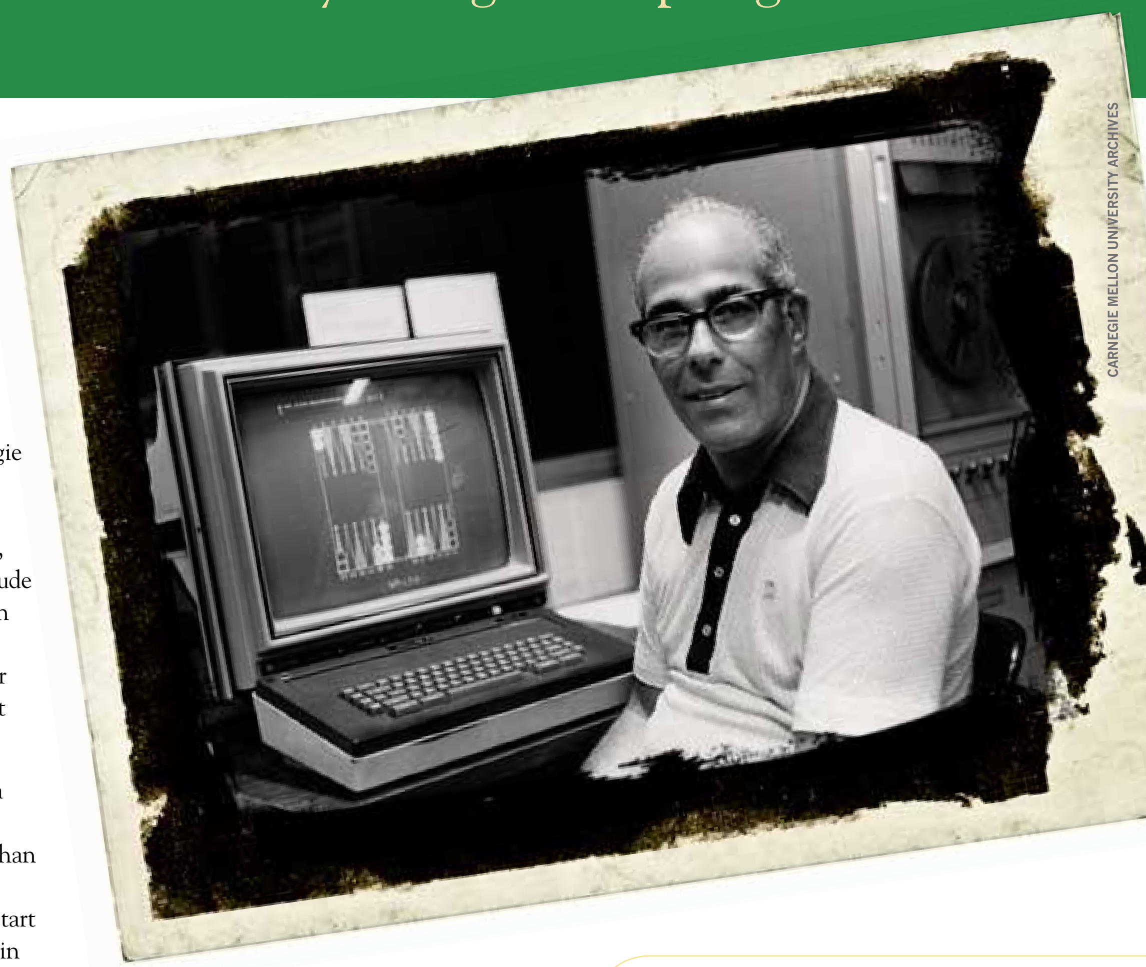
- Mary Jo Bensasi, senior operations assistant in LTI, staff award for "individual dedication";
- Mark Penney, SCS payroll specialist, and Indra Szegedy, administrative coordinator in the Human-Computer Interaction Institute, staff awards for "rookies of the year";
- Cleah Schlueter, administrative associate, dean's office, staff award for "citizenship";
- Catharine Fichtner (A'95), senior undergraduate program coordinator in CSD, and Becky Klaas, associate business manager in the Robotics Institute, staff awards for "sustained excellence";
- Kelly Widmaier, research administrative assistant in LTI, staff award for "rising star"; and
- Jo Bodnar, administrative associate in HCII, and Jane Miller, associate director for foreign initiatives and program manager in the Institute for Software Research, awards for "outstanding staff."

—Jason Togyer (HS'96)

THE ICONOCLAST



CMU's Hans Berliner (CS'75) was at the center of the decades-long worldwide quest to build a computer that could beat a human chess champion—a race that ended 15 years ago this spring.



CARNEGIE MELLON UNIVERSITY ARCHIVES

> **By Jason Togyer**

Do you want to understand the history of computer science? You might want to start with computer chess.

"If you look at the names associated with advances in computer chess, you'll find most of the people who founded the entire field of computer science," says Daniel Sleator, Carnegie Mellon professor of computer science and a founder of the Internet Chess Club. Those pioneers include Alan Turing; Ken Thompson, co-inventor of the Unix operating system; Claude Shannon, inventor of information theory; John McCarthy, inventor of the LISP programming language; and the founders of CMU's computer science department, Allen Newell and Herbert Simon.

Computer chess has been called the drosophila—fruit fly—of artificial intelligence, or AI, research. If you're studying genetics, says Jonathan Schaeffer, a professor of computer science and vice provost of the University of Alberta, you start with fruit flies, because they live, mate and die in a few days, and multiple generations of a mutation can be observed quickly.

"Chess—like the fruit fly—allows us to have a controlled domain where we can experiment with lots of issues in intelligence," says Schaeffer, who led the team that designed Chinook, a computer checkers program that seems to be unbeatable, and who also leads the university's computer poker research. "We start with something simple that we can understand, and once we progress beyond chess, we move onto harder problems."

One remarkable man spent two decades at the center of computer chess research: CMU senior research scientist Hans Berliner (CS'75). It was Berliner who built the first game-playing computer ever to defeat a human champion and the first chess computer capable of playing at "senior master" level, and it was Berliner who 15 years ago this May awarded the Fredkin Prize in Artificial Intelligence to IBM's Deep Blue—the machine, designed by three CMU alumni, that defeated world chess champion Garry Kasparov.

Today, retired and living in Florida, Berliner is characteristically blunt. Computer chess was "a research dead-end" as far as artificial intelligence was concerned, he says.

"The whole AI thesis was wrong," Berliner says. "AI researchers thought more knowledge would do everything." As it turned out, more powerful >>>

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Jonathan Schaeffer, University of Alberta

CARNEGIE MELLON UNIVERSITY ARCHIVES

Berliner, shown here watching one of his early programs compete in a chess match, "led by example more than anything else," says one of his former students. Another remembers Berliner's "graciousness," adding that "working with Hans was a lot of fun."

processors and machine-learning techniques powered by statistical analysis, not human-devised rules, were able to crack data-intensive problems in speech, image analysis and data retrieval.

But although computer chess may not have been the Rosetta stone to understanding and simulating human intelligence, those who've studied Berliner's work say his research was no dead-end.

"He covered a lot of ground, and he achieved excellence in all of those areas," says Murray Campbell (CS'87), one of the members of the IBM Deep Blue team.

"It would have been nice to say that computer chess led to a huge breakthrough that allowed us to better understand human language or translation, or led to a general model of human intelligence, but it didn't," Campbell says. "It did lead to a change of mind, a change in attitude, about how we approached a large number of problems in computer science. And in this field—and this is an important point—Hans Berliner produced something that had lasting value."

Berliner "never took the easy way," Schaeffer says. As a result, Berliner "has a legacy of excellent papers that contain insights, algorithms and new ideas that aren't as common today as they should be. People continue to reference his work when they realize there are other ways to do things, and then they point at Hans.

"Most scientists aren't willing to take the kinds of risks that Hans would take," Schaeffer says. "But that's why his papers are still around, while the papers of his contemporaries are long gone and forgotten."

Taking risks may be embedded in Berliner's DNA. His great-uncle Emile Berliner invented the gramophone—better known as the phonograph. Although Thomas Edison generally gets credit for inventing recorded sound, his cylindrical records were difficult to manufacture and store. Emile Berliner perfected recorded discs—superior to Edison's records in every way, and arguably the predecessor of all formats that followed, including hard drives and Blu-ray discs.

Another relative took a risk and rescued Hans Berliner and his family from a potentially awful fate. Born in Germany in 1929, Berliner entered public school just as Adolf Hitler was rising to power. The first hour of each of his school days consisted of "religion" (meaning, "Christianity") and "National Socialism." Berliner wasn't allowed to participate in those activities, and he couldn't join his friends in the Hitler youth. "I was told that I was Jewish, and they didn't want me," he says. "That was quite a shock, and I guess that's one of those things that sort of grows you up a little bit."

Yet in other ways, Germany was a wondrous place—"probably the best place in the world," he says—for a child interested in science. "The Germans were full of inventiveness and managed to produce things that were very, very good," says Berliner, who remembers having a metal wind-up car that sensed when it was about to run off of a ledge and automatically steered away. "This was a child's toy with a real, working servomechanism in 1935 or thereabouts," he says. "I thought it was fantastic—and it was." While kindergarteners in the United States were finger-painting, Berliner and his German classmates were probably "three years ahead" in mathematics. Those formative years "had a very positive effect on me," he says.

But the atmosphere in Hitler's Germany promised nothing except despair, and Berliner's parents knew it. In 1936, two visitors from the United States came to stay with the Berliner family. Seven-year-old Hans was soon shocked to learn that the family was leaving Germany. A nephew of Uncle Emile, Joseph Sanders, had arranged for about 10 members of the extended family to emigrate to America.

Along with his family, Berliner arrived in the Washington, D.C., area speaking very little English, and that with a thick German accent. But he doggedly pursued his studies and would graduate high school with the top grammar marks in his class. Years later, one of his fellow students at Henry D. Cooke Elementary School, Mexican novelist and essayist Carlos Fuentes, vividly remembered Berliner, the "extremely brilliant boy" with "deep-set, bright eyes … a brilliant mathematical mind … and an air of displaced courtesy that infuriated the popular, regular, feisty, knickered, provincial, Depression-era sons-of-bitches."

It was a rainy day at summer camp when a teen-age friend taught Berliner to play chess. "I saw these kids doing this thing on a board, and it wasn't checkers, which I was pretty good at," Berliner says. "So I learned the moves, and by the end of the day, there was already someone I was beating regularly. I like to say I was never the worst player in the world." Chess was a wonderful way to discipline his mind, Berliner says. "You're forced to deal with a certain level of reality," he says. "It's up to you to do something that improves your prospects in a certain way. If you've trained yourself and you have the proper machinery between your ears, you can think quite far ahead." By age 20, Berliner had achieved master status, winning the District of Columbia Championship and the Southern States Championship.

Campbell, the 1977 Alberta chess champion, says Berliner wasn't a "star" player in the mold of Bobby Fischer or Garry Kasparov, but achieved chess greatness "using a very systematic approach and a lot of hard work." Now a senior manager at IBM's Thomas J. Watson Research Center in Yorktown Heights, N.Y., Campbell says Berliner "had competitive fire" and an analytical mind that enabled him to beat players "who might very well have been more talented than him."

While Berliner could evaluate chess moves six or eight "plies" (one move by one player) deep, real-life proved trickier to navigate. He remembers feeling adrift—that "the future was there, and you didn't have to do anything about it, because it would come to you." After high school, he entered George Washington University to pursue a degree in physics—"a mini-catastrophe," he says, because courses were taught by rote memorization, and as his grades plummeted, the draft beckoned. Berliner served his time in the U.S. Army with the German occupation forces. Throughout his tour of duty, Berliner continued to play chess, including one exhibition where he kept eight games going simultaneously against one of the top German teams—and won them all.

Upon his return to civilian life, Berliner came back to Washington determined not to re-enter college. Local lumber magnate Isador Turover set Berliner straight. A fellow European immigrant who knew Berliner through chess circles, Turover told the younger man in no uncertain terms, "You will finish your degree." Turover hired Berliner into his company so that he could pay his way through GWU, though Berliner switched from physics to psychology. "I was so naïve, I thought that when I got a degree in psychology, I could hang out my shingle as a psychologist and start counseling people," he says. Again fate intervened. A classmate who worked at the Naval Research Lab told Berliner, "We need people like you where I work." Berliner wound up working for the federal government on problems in what was then called "human engineering" or "engineering psychology"—a predecessor to today's studies of interface design.

In chess circles, his ranking kept increasing—Berliner represented the United States at the 10th Chess Olympiad in Helsinki and won the 1953 New York State Championship, the 1956 Eastern States Open and the 1957 Champion of Champions Tournament. By this time, he was playing games blindfolded. "Two times, I think, I played six games at a time without sight of a board," he says. "Both times, I got an incredible migraine headache, so that was not a smart thing to do."

His reputation grew especially strong in correspondence chess—games played through the mail—and from 1965 to 1968, Berliner was the World Correspondence Chess Champion. His first championship is the stuff of legends; Berliner won 12 of 16 and drew four times, giving him a margin of victory three times better than any other winner. He remained the top-ranked U.S. correspondence chess player until 2005, long after he stopped competing. >>>

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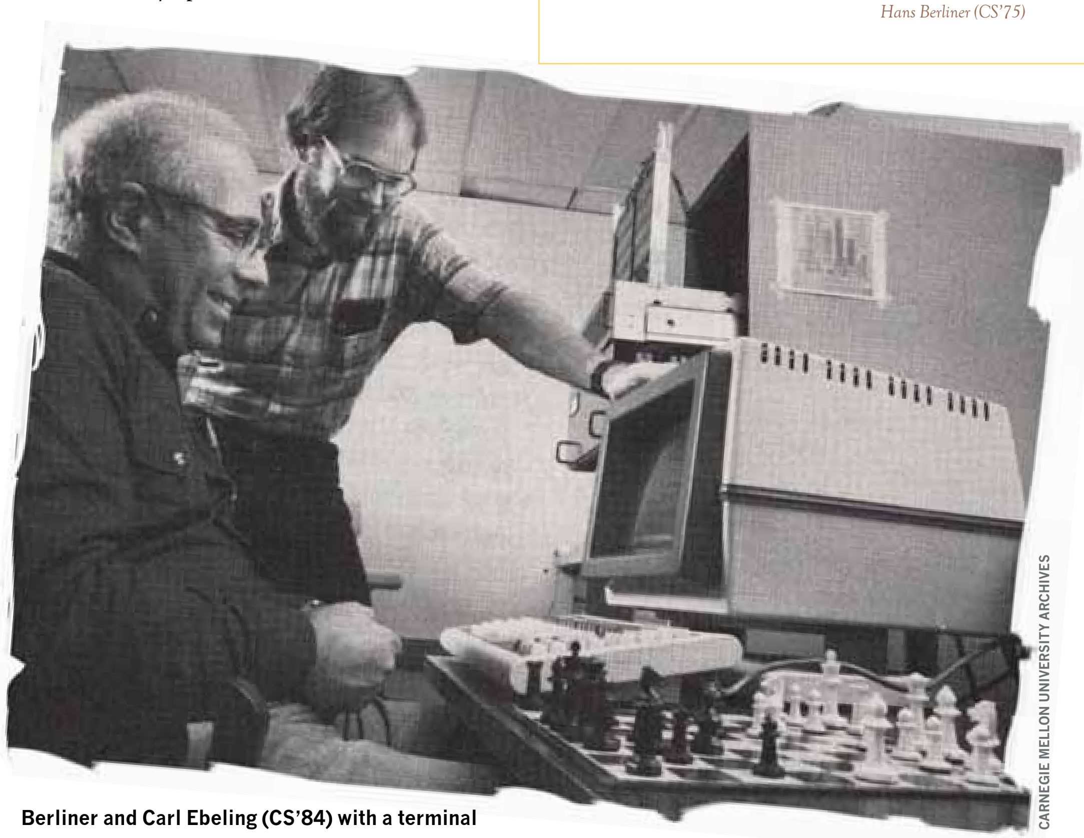
Hans Berliner (CS'75)



CARNEGIE MELLON UNIVERSITY ARCHIVES

Berliner and Carl Ebeling (CS'84) with a terminal linked to Hitech, which by 1987 had become the top chess-playing computer in the United States.

Though Berliner never considered making chess his professional life, his career trajectory was less than fulfilling. From the naval lab, Berliner went to Martin aircraft, General Electric and IBM. "My pay was skyrocketing, but I had an awful lot of spare time," he says. Nearing 40 and feeling frustrated, Berliner in 1967 met future Nobel laureate and Turing Award winner Herb Simon at a technical meeting.

> "It's known to be a very challenging game, and it takes intelligence to play it, yet it's limited in very nice ways. With chess, you don't have to 'boil the ocean' to make progress. You can focus on an interesting subset and make some progress."
>
> *Murray Campbell (CS'87)*

In 1956, Simon, associate dean of what was then known as CMU's Graduate School of Industrial Administration, had predicted (to his later chagrin) that within 10 years a computer would become world chess champion. Two years later, with Allen Newell and Cliff Shaw, Simon wrote one of the first chess-playing programs, known as NSS. Berliner remembers being unimpressed with NSS, which took up to an hour to make a move: "They could play against some human who played even worse, but it couldn't come close to beating a ranked player."

More than a decade later, Simon remained interested in chess computers. He offered Berliner a job. Berliner turned him down. "If I'm going to come there, you've got to put me on the student track," he said.

"Who knows what my thinking was?" Berliner says now. "I was at the point where I felt like I wanted to do something with my life—something worthwhile." Simon agreed and Berliner was accepted into CMU's four-year-old Computer Science Department, arriving in 1969 to find a "good" but "chaotic" environment, "up on wobbly feet." The department's founding head, Alan Perlis (S'43), "was an amazing, wonderful person," Berliner says. "He wasn't perfect and he wasn't always right, but he had a desire for progress and truth that was very, very commendable … he was sort of the guiding light for us and in a sense, the lifeblood of the Computer Science Department."

All new graduate students were expected to pass a rigorous 24-hour take-home exam, the Extended Duration Qualifier. Berliner found it impenetrable, but in the meantime, Newell allowed him to start his thesis—"because I wanted to work on computer chess," he says.

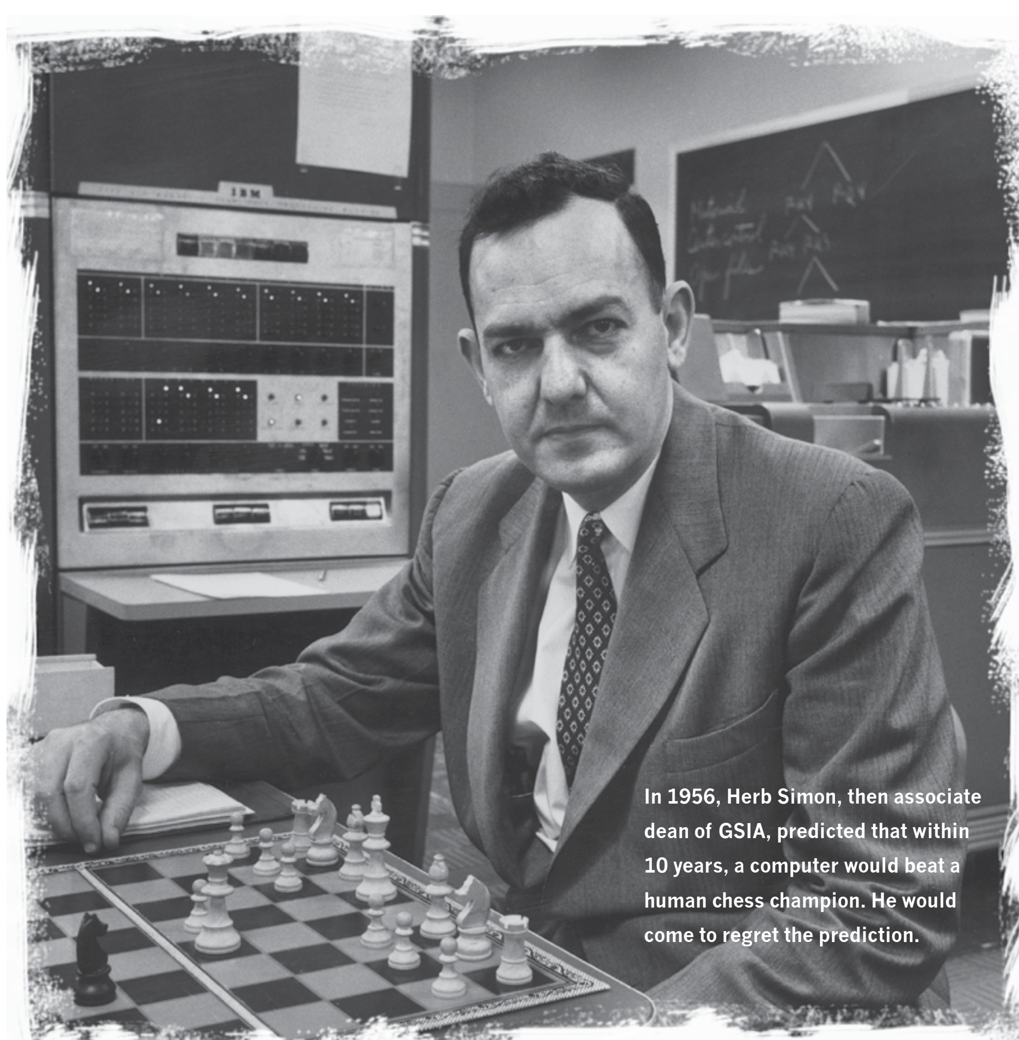
As far back as the 1940s, Alan Turing was pointing out that if games can be described by a series of mathematical operations, and computers can execute mathematical operations, then computers can play games such as chess. In 1950, Turing wrote a rudimentary chess program, though he lacked a computer capable of executing it.

Newell, Simon and Shaw's chess program was an outgrowth of their Logic Theorist, a program designed to prove the theorems of the Principia Mathematica in a way that emulated human reasoning. Each problem was represented as a tree, with a hypothesis at its "root" and each rule of mathematical logic represented as a "branch." If a rule was untrue for that hypothesis, that branch was "pruned" and the program went to the next branch. If a rule was proved true, the program went further down that branch to the next operation. (Today, this is called "traversal" of a tree or graph.) In that way, the program eventually arrived at a formal proof. Widely considered the world's first "artificial intelligence" program, Logic Theorist generated proofs for 38 of Principia Mathematica's first 52 theorems, including one that was simpler than the commonly accepted proof.

For the next 20 years, search trees and "pruning"—using heuristics—formed the basis for most AI programs. Programs that attempted to play chess, generate proofs or solve other problems by calculating all known positions were derided as using "brute force;" top researchers like MIT's Claude Shannon declared flatly that brute-force methods would never work.

Chess is particularly useful for AI research because it's bound by rules, unlike more abstract problems in speech or vision, Campbell says. "It's known to be a very challenging game, and it takes intelligence to play it, yet it's limited in very nice ways," he says. "With chess, you don't have to 'boil the ocean' to make progress. You can focus on an interesting subset and make some progress."

Another of Berliner's students, Carl Ebeling (CS'84), now a professor of computer science



In 1956, Herb Simon, then associate dean of GSIA, predicted that within 10 years, a computer would beat a human chess champion. He would come to regret the prediction.

CARNEGIE MELLON UNIVERSITY ARCHIVES

Alan Perlis (S'43), founding head of the CMU Computer Science Department, was an "amazing, wonderful person," Berliner remembers. "He had a desire for progress and truth that was very, very commendable."

at the University of Washington, says that many problems in AI research rely on measurements, statistics and analysis, and the results are hard to tease out. "In chess, it's not hard to figure out if something is working or not. You can't B.S. people. If your program doesn't win, there may be a lot of reasons why it lost, but it's hard to make excuses."

Alberta's Schaeffer adds that if a researcher is trying to build an "intelligent" machine, "and it can't even play a simple game such as chess, then clearly you have a long way to go." In the 1970s, when Schaeffer was beginning his own studies in computer science, "chess was the game, par excellence, that everyone was researching, and when you looked at the high-quality scientific venues, the premier journals, there was only one person in the entire community who was publishing there, and that was Hans Berliner."

Berliner's first chess program was also his first computer program of any kind. Written at IBM on his own time, it was called "J. Biit"—"Just Because It Is There." J. Biit came to CMU with Berliner and was an early favorite to win the first North American Computer Chess Championship, but it lost to Northwestern University's Chess 3.0. His next program, written as he worked on his doctoral thesis, titled "Chess as Problem Solving," remembered the errors it had previously made and learned to avoid them before beginning a new search. Yet even as Berliner refined the program, called "CAPS," he became convinced that rule-based chess programs weren't enough to defeat a human champion.

Although their goal was to imitate human decision-making, they left no room for intuition or guesswork. "I had a set of rules that were limited," Berliner says. "They were the most important things—maybe 80 percent—but that's nothing. The other 20 percent includes the things the top players know how to do. That's why they're the top players." Newell and Simon kept pressing Berliner to push onward: "Allen would say, 'you're not trying hard enough—you've got to make up more rules.'"

As he looked for a new avenue for his research, Berliner learned the game of backgammon from his father-in-law. Simpler than chess, backgammon requires both luck and strategy; players start with their checkers stacked at three different points on the board and move them based on rolls of the dice, and the first player to move all of his or her checkers off the board wins. Berliner decided to write a backgammon program. At first, it would get to a certain point and then start to bog down. "It kept trying to optimize things that it should have forgotten about," he says. "At some point, you're not just winning, you've actually won, and your strategy should change at that point—you should be aware that a transition is coming."

Berliner hit on the idea of using fuzzy logic—still a new concept in the 1970s—to assign different rules "weights," or "application factors," based on their relative importance at each stage of the game. Now, the program, called BKG, started winning games it would have previously lost. In July 1979, it became the first computer program to beat a reigning world champion in any game when it defeated backgammon player Luigi Villa. Despite the success, Berliner found himself pigeonholed. One of his papers on BKG was returned by an AI conference with a note from a reviewer: "Why isn't Berliner working on chess?"

But Berliner was working on chess. "A lot of the work in computer chess was ad hoc—it was done by hobbyists for fun, and never got published," Schaeffer says. "Hans was a scientist, first and foremost. He tackled chess with scientific rigor, and as he discovered new ideas or insights, he published them properly—not in weak, mediocre conferences, but at the top, in the premier journals and conferences."

Campbell was drawn to CMU on the strength of Berliner's research in chess. "I read some of his papers, and that was where I wanted to be," he says.

One of the highlights of Berliner's research in those years was the B* ("B-star") algorithm, designed to emulate what he calls the "jumping around" process in human thought. Most tree searches were performed either best-first or depth-first. Best-first searches find the lowest-cost path to a goal, going from branch to branch as necessary, while depth-first searches explore every branch on a tree to its end until reaching a goal. As Berliner saw it, both searches had serious drawbacks—depth-first searches wasted time, while best-first searches required a lot of effort to keep track of alternate paths. Perhaps the worst problem—from his perspective—was that both searches were strictly goal-oriented. They had to be arbitrarily terminated or else they would keep trying to reach a goal, bypassing "good enough" paths while trying to find an optimal solution. Like the first version of Berliner's backgammon program, they didn't know when to quit.

The answer came to Berliner in the middle of the night. Rather than writing an algorithm that searched a tree based on hard-and-fast >>>

Herb Simon and Allen Newell (TPR'57) designed the chess program NSS in 1958 along with Cliff Shaw. Berliner was "unimpressed" with the program, which was able to beat a novice human player. He later clashed with Simon and Newell over their insistence on rule-based chess programs.

CARNEGIE MELLON UNIVERSITY ARCHIVES

limits, Berliner's B* algorithm assigned an "optimistic" and a "pessimistic" score to each node. The algorithm kept searching a branch as long as the pessimistic value of the best node was no worse than the optimistic value of its sibling nodes. B* found paths that were sufficient to a task rather than theoretically "perfect" ones—emulating the way that a human chess master will stop when she or he finds a move that seemed to be clearly the best.

"B* tried to use the power of computers to search in a way that was like a rational human being would search," says Andy Palay (CS'83), now at Google. Unlike simple A* "best-first" searches, B* is "a much more directed search toward what appear to be the most promising paths," says Palay, who wrote his doctoral thesis on ways of extending the B* algorithm using a probability distribution rather than upper and lower ("optimistic" and "pessimistic") values.

It was Palay who suggested applying B* to chess. There are between 30 and 60 legal moves at any given point in a chess game, and searching for those legal moves consumed up to 75 percent of a chess computer's time. In a chess tournament, each player is allowed an average of only three minutes to make a move. In the early 1980s, when the fastest processor had a 10 MHz clock speed, efficient searching was a key to success. "There's no trick to solving chess with brute-force searching if you're in a domain that's constrained enough," Palay says. "If I can out-search everyone, I win. But life isn't that simple. That's why I found B* much more interesting."

Palay talked to Berliner about his friend Carl Ebeling, who was looking for a thesis project that involved hardware. Using the then-novel technology of very-large-scale integrated, or VLSI, circuits, Ebeling custom-designed a processor to generate chess moves. The resulting machine, named Hitech, used 64 of these processors—one for each square of the chessboard—operating in parallel; a master control program polled the processors and decided strategies. People inside and outside CMU's CS department took turns at a third-floor lab in Wean Hall, wire-wrapping connections. "There was such an enthusiasm for Hitech that I've never seen before," Berliner says. "Everyone wanted to know what the latest developments were, and if they could help."

A working prototype was completed in 1984. Although Hitech searched smarter, it also employed a certain amount of brute force; Hitech could consider 175,000 positions per second. (A top human player might look at one or two moves per second.) In October 1985, Hitech won Pittsburgh's Gateway Open chess competition, earning the rank of "master." That year it also won the ACM tournament for chess programs. By 1987, it was ranked 190 in the United States and the only computer among the top 1,000 players.

Campbell was among those working on improving Hitech's search algorithms. As smart and flexible as the machine was, he says there was a growing feeling that it "didn't have the horsepower" to beat a human grandmaster.

The field itself was changing. One of the developers of the Unix operating system, Ken Thompson of Bell Labs, created his own powerful chess-playing machine that reached master-level status. In 1982, Thompson published what Schaeffer describes as "an innocuous little paper" that proved that chess machines improve in direct correlation with the amount of processing power they have.

After Thompson's paper, "chess research died," Schaeffer argues. For many researchers, the race was no longer to create smarter searches, but faster computers.

Besides working on Hitech, Campbell also was collaborating with fellow grad students Feng-hsiung Hsu (CS'90) and Thomas Anantharaman (CS'86,'90) on another chess-playing computer that became known as ChipTest. Like Hitech, it relied on VLSI technology, but it was much faster—by 1987, the year it won the North American Computer Chess Championship, ChipTest was searching 500,000 moves per second.

Danny Sleator remembers the rivalry between the Hitech and ChipTest teams. "The fact that we had two competing chess systems developed at CMU simultaneously reflects a number of important things about the culture in the Computer Science Department," Sleator says. "For one thing, there is a tremendous amount of respect for the work of graduate students. The faculty gives them the benefit of the doubt, and in many cases, including this one, it pays off. The place is also big enough and tolerant enough that more than one group can work on the same problem using different approaches."

In the early days, “there was some good cross-pollination” between the rival groups, says Campbell, but the relationship deteriorated. “There was some tension that never got resolved, and there were some hard feelings in terms of the competition between the two groups,” he says. ChipTest evolved into Deep Thought, which won the World Computer Chess Championship in 1989. IBM hired Hsu, Campbell and Anantharaman; Hsu and Campbell led development on the machine that became Deep Blue and beat Kasparov in 1997.

Deep Blue was massively parallel, including 480 special-purpose chips designed to evaluate chess moves. It also demonstrated conclusively that brute-force computing power could crack tough problems. “My greatest regret, to this day, is that Deep Blue wasn’t really a ‘learning’ system,” Campbell says. Teaching a machine to play chess the way that humans learn still hasn’t happened, he says. “You can take an existing program and ‘tweak’ it using machine-learning techniques to play better, but to teach it to play from next to nothing—how people learn—is still beyond reach,” Campbell says. “I think that’s a fascinating thing.”

Kasparov claimed to have seen “human intelligence” behind Deep Blue’s moves—a statement some interpreted as an allegation that IBM cheated, and which the Deep Blue team said was not true. Berliner says it would be a mistake to assume that a system based on the statistical analysis of massive data sets isn’t a form of intelligence. “Intelligence emerges just like life emerges,” he says. “You take a bunch of inert chemicals which can replicate themselves, and they form into a creature. It’s the same thing with intelligence. We can talk about something being ‘intelligent’ when it meets some certain criteria, but certainly even the dumbest living thing has some sort of intelligence, or it wouldn’t stay alive.” In that respect, Berliner says, Kasparov certainly saw intelligence in Deep Blue—but machine intelligence, not human intelligence.

Berliner also sees intelligence in Deep Blue’s descendant, IBM’s “Jeopardy!”-playing machine, Watson, which he calls “quite marvelous.” Just as notable as Watson’s ability to answer “Jeopardy!” questions is its understanding of slang and idiom, Berliner says. “I’ve worked in that area of general intelligence, and it’s not easy,” he says.

But Berliner being Berliner, he doesn’t hesitate to point out where Watson had an unfair advantage over its human competitors. Watson received the Jeopardy! answers in written form and could immediately get to work, while the human players were still listening to and parsing the text. “The computer was way, way ahead in understanding the question—maybe a second or two ahead—so 90 percent of the time, it rang in before the human,” Berliner says. “That gives it a tremendous advantage. It was very, very smart to get the answers, but many of the human beings never got a chance to show what they knew.”

Berliner’s willingness to question conventional wisdom and preconceived notions—including his own—has led to no small amount of controversy over the years. “I have very high standards for myself,” he says. “In the end, the only things we have to offer the world are those standards.”

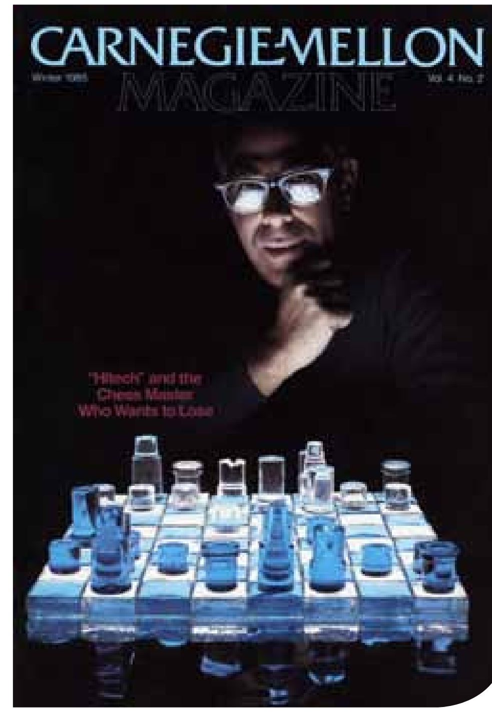
When Berliner decided the work of Russian computer scientist and chess grandmaster Mikhail Botvinnik didn’t maintain high standards, he pulled no punches. After concluding that Botvinnik’s published results couldn’t be duplicated, he accused the venerable old champion of fraud. Botvinnik’s fans attacked Berliner, but Schaeffer and others reviewed Berliner’s evidence and concluded that Botvinnik indeed massaged his published results to achieve his outcomes. Berliner’s 1999 book “The System: A World Champion’s Approach to Chess” attracted sharp criticism from a few professional reviewers, but the sometimes very personal attacks left Berliner unbowed.

“A lot of people saw the significant value in what he did,” says Campbell, who points out that in both the Botvinnik case and the strategy book, Berliner refused to take an easier path just to avoid unpleasantness. “There’s a lot to be said for that. It can be lonely, and it takes a strong personality to be able to do that, and he has that kind of personality.”

His former students say Berliner’s reputation as a fearless advocate has overshadowed his generous spirit. “Working with Hans was a lot of fun,” Palay says. “There was a great deal of graciousness, both on a personal level and a professional level. He was very much concerned with making sure that he was treating me well, not just as his student, but as a person.” Palay says he consciously mimics Berliner’s style when interacting with his own colleagues.

“You can’t become a top-rated chess player like Hans without being competitive and self-confident, but I never saw him as being ‘over the top,’” Ebeling says. “He led by example more than anything else. There was a constant attention to detail, and he was always thinking, looking out for the next idea that might work.”

Berliner’s research legacy “might not at all be guessable at this point,” says Palay, though he notes the pendulum seems to be swinging back from purely statistical machine-learning methods in translation and other fields to hybrids that include rule-based search techniques. “Some of the things that he was working on will resurrect themselves over time, as we start hitting walls,” Palay says. “Tracing them back to Hans will be difficult, but the seeds will be there.”



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Hans Berliner on the cover of Carnegie-Mellon Magazine at the height of Hitech’s success. The machine was surpassed by ChipTest, a project of CMU grad students Thomas Anantharaman (CS’86,’90), Murray Campbell (CS’87) and Feng-Hsiung Hsu (CS’90). Members of the ChipTest team eventually built Deep Blue, the IBM computer that defeated human chess champion Garry Kasparov in 1997.

As computer scientists try to reduce power consumption and face difficulty adapting some problems to parallel computing, they’ll look for more efficient search algorithms, Schaeffer predicts—and they’ll find that Hans Berliner got there first. “We may find that maybe we don’t need all of this massive computing power, maybe you don’t need this sledgehammer of brute-force computing,” he says, but adds that Berliner’s most lasting legacy is his graduate students. “He didn’t have many, but they were of very high quality.”

These days, Berliner is out of the fray. He doesn’t play chess—“once you get to a certain level, you don’t enjoy playing chess any more,” he says—but he does work on his solitaire game, and keeps records of winning strategies. When the weather’s good, Berliner finds peace strolling the beach and thinking.

Before retiring from CMU in 1998, Berliner says he saw a “deplorable trend” among some students of attempting to talk their way around difficult problems instead of performing the necessary research. His advice to today’s students? “Learn all the substantive knowledge that you can,” Berliner says. “In the final analysis, all knowledge hangs together, and the more you know, the easier it will be to make good decisions in the future.

“Learn something that has value—something quantitative, hopefully. Have something you can do that someone else will want to pay you for—a product. If you don’t have that, it’s going to be tough for you.”

—Jason Togyer (HS’96) is editor of The Link.

Matching Images Across Domains Using "Data Uniqueness"

> By Abhinav Shrivastava, Tomasz Malisiewicz, Abhinav Gupta and Alexei Efros

(Editor's Note: This is a drastically condensed version of a paper called "Data-driven Visual Similarity for Cross-domain Image Matching" presented at SIGGRAPH Asia. In order to fit this format, data, algorithms and formulae in the original have been eliminated. To read the entire paper, please visit graphics.cs.cmu.edu/projects/crossDomainMatching.)

Powered by the availability of Internet-scale image and video collections coupled with greater processing speeds, the last decade has witnessed the rise of data-driven approaches in computer graphics and computational photography.

Data-driven approaches use visual data directly, without an explicit intermediate representation. These approaches have shown promising results on a wide range of challenging computer graphics problems, such as removing visual "noise," synthesizing textures, colorizing black-and-white images, replacing missing parts of scenes and creating realistic virtual spaces. The applications range from restoring historic photos to improving visual simulations, to give but a few examples.

The central element common to all these approaches is searching a large dataset to find visually similar matches to a given query. Yet defining a good visual similarity "metric" to use for matching can be surprisingly difficult. In many situations where the data is reasonably homogeneous—different patches within the same texture image, or different frames within the same video—a simple "sum of squared differences" formula at a pixel-by-pixel level works quite well.

But what about the cases when the visual content is similar on a high level (two pictures of the same bridge) but very dissimilar on a pixel level (a painting of the bridge, versus a photograph)?

Methods that use scene matching often need to match images across different illuminations, different seasons, different cameras, etc. Likewise, retexturing an image in the style of a painting requires making visual correspondence between two very different domains—photos and paintings.

Cross-domain matching is even more critical for applications such as Sketch2Photo and CG2Real, which attempt to create photo-realistic images from simple sketches or CG renderings. In all of these cases, pixel-level matching fares quite poorly.

What is needed is a visual metric that can capture the important visual structures that make two images appear similar, yet ignore superficial (for our purposes) visual details such as texture or color. The visual similarity algorithm somehow needs to know which visual structures are important for a human observer and which are not.

Currently, the way researchers address this problem is by using various image feature representations that aim to capture high-gradient and high-contrast parts of an image, while downplaying the rest. Such representations are very helpful in improving image-matching accuracy for a number of applications.

However, what these features encode are purely local transformations—mapping pixel patches from one feature space into another, independent of the global image content. The problem is that the same local feature might be unimportant in one context but crucially important in another.

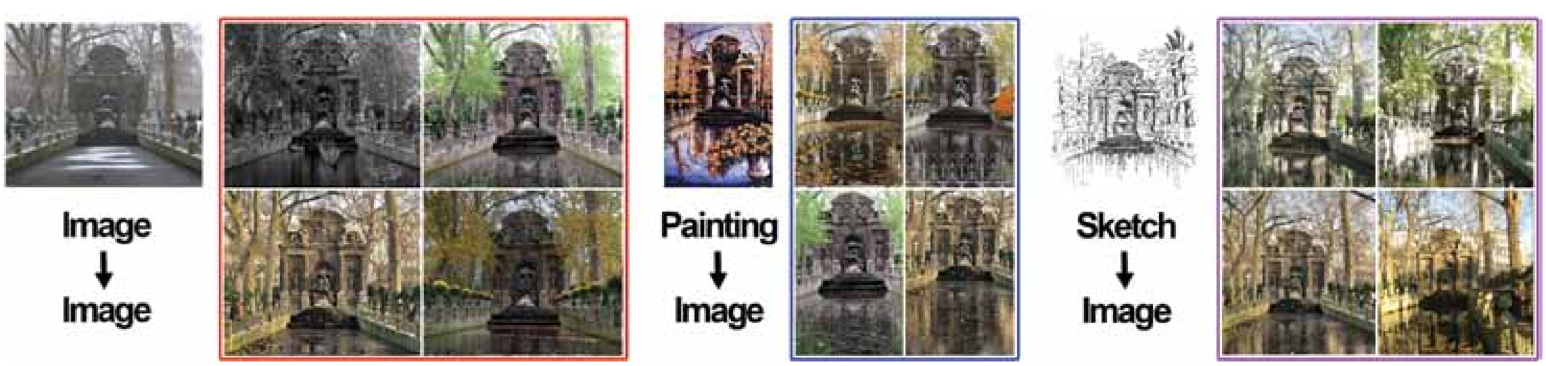


Figure 1

Consider, for example, the painting in Figure 1. At a pixel-by-pixel level, the brush-strokes on the alleyway are virtually the same as the brush-strokes on the sky. Yet, the former are clearly much more informative as to the content of the image than the latter and should be given a higher importance when matching. To do this algorithmically requires not only considering the local features within the context of a given query image, but also having a good way of estimating the importance of each feature with respect to the particular scene's overall visual impression.

What we present in this paper is a very simple, yet surprisingly effective approach to visual matching that is particularly well-suited for matching images across different domains. Given an image represented by some features, the aim is to focus the matching on the features that are the most visually important for this particular image. The central idea is the notion of "data-driven uniqueness."

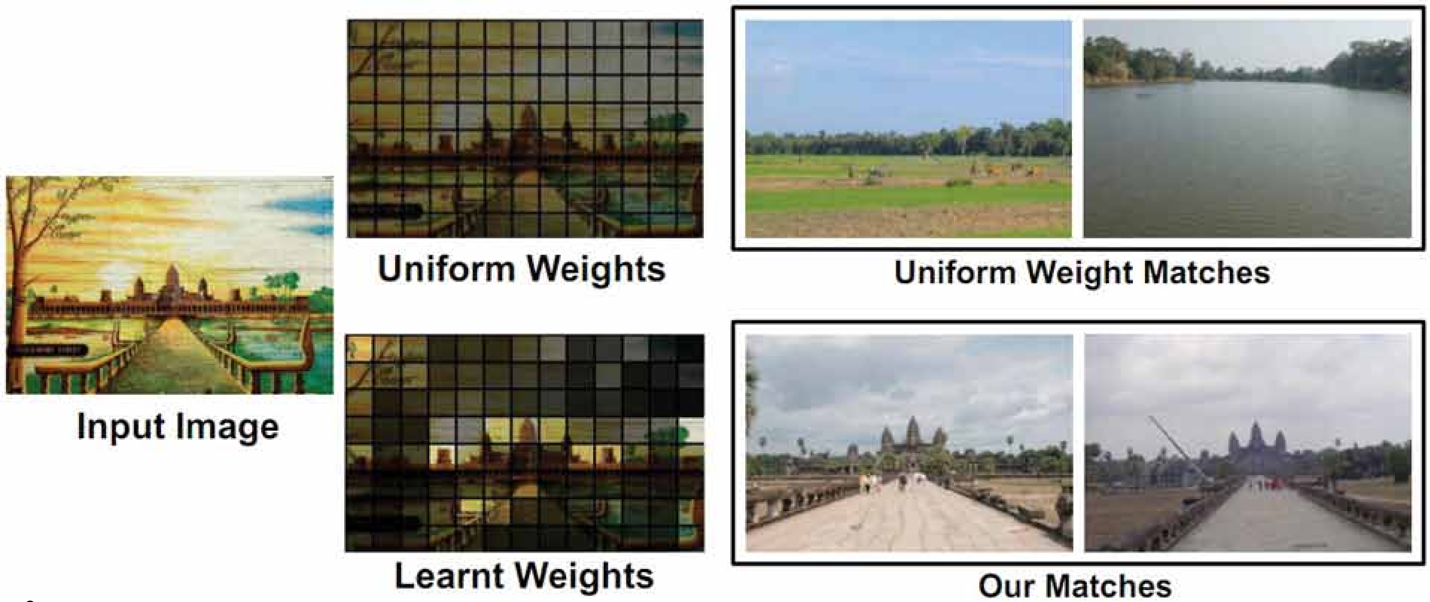


Figure 2

We hypothesize that the important parts of the image are those that are more unique or rare within the visual world. For example, in Figure 2, the towers of the temple are very unique, whereas the wispy clouds in the sky are quite common. However, since the same local features could represent very different visual content depending on context, our notion of uniqueness is scene-dependent—each query image decides what is the best way to weight its constituent parts. Figure 2 demonstrates the difference between image matching using a standard uniform feature weighting vs. our uniqueness-based weighting.

We define this data-driven uniqueness by using ideas from machine learning—training a discriminative classifier to discover which parts of an image are most discriminative in relationship to the rest of the dataset. This simple approach results in visual matching that is surprisingly versatile and robust. By focusing on the globally salient parts of the image, the approach can be successfully used for generic cross-domain matching without making any domain-specific changes, as shown on Figure 1.

Background

In general, visual matching approaches can be divided into three broad classes, with different techniques tailored for each:

Exact matching: For finding more images of the same physical object (e.g., a Pepsi can) or scene (e.g., another photo of the Eiffel Tower under similar illumination), researchers may use a technique introduced in 2003 by Josef Sivic and Andrew Zisserman in their Video Google retrieval system. This paradigm generally works extremely well, especially for heavily textured objects, and has led to many successful applications such as Google Goggles. However, these methods usually fail when tasked with finding similar but not identical objects—try using the Google Goggles app to find different kinds of cups or chairs. It captures the details of a particular object well, but not necessarily its overall global properties.

Approximate matching: The task of finding images that are merely "visually similar" to a query image is significantly more difficult, and none of the current approaches can claim to be particularly successful. Most employ various image representations that try to capture the important, salient parts of the image. (Also related is the vast field of Content-Based Image Retrieval, or CBIR, in which we attempt to find relevant images even when they don't seem to be visually similar—for instance, an image of a steam locomotive might be considered relevant to an image of a bullet train if we were searching for images of trains, even though they have very little in common visually. Most modern CBIR methods combine visual information with textual annotations and user input.)

Cross-domain matching: A number of methods exist for matching between particular domains, such as between sketches and photographs, paintings and photographs, or photographs taken under different lighting conditions. However, many of these have very domain-specific solutions that aren't easily applied to other domains.

Most closely related to ours are approaches that try to learn the statistical structure of natural images by using large unlabeled image sets, as a way to define a better visual similarity. However, these systems require multiple positive query images and/or user guidance. The visual matching tasks that we are interested in need to work automatically and with only a single input image.

Fortunately, recent work in visual recognition has shown that it's possible to train a discriminative classifier using a single positive instance and a large body of negatives, provided that the negatives do not contain any images similar to the positive instance. In this work, we adapt this idea to image retrieval, where one cannot guarantee that the "negative set" will not contain images similar to the query. (On the contrary, it most probably will!) What we show is that, surprisingly, this assumption can be relaxed without adversely impacting the performance.

Our Approach

The question remains: How can we compute visual similarity between images in a way that would be more consistent with human expectations? (For instance, to use our earlier example, finding images of "cups" or "chairs.") The main difficulty is in developing the right function to "pick" which parts of the representation are most important for matching.

In our view, there are two requirements for a good visual similarity function:

1) It has to focus on the content of the image >>>

(the "what"), rather than the color, texture or style (the "how").

2) It should be scene-dependent—each image should have its own unique similarity function that depends on its global content. This is important since the same local feature can represent vastly different visual content, depending on what else is depicted in the image.

The visual similarity function that we propose is based on the idea of "data-driven uniqueness."

We hypothesize that what humans find important or salient about an image is somehow related to how unusual or unique it is. If we could re-weight the different elements of an image based on how unique they are, the resulting similarity function would, we argue, answer the requirements of the previous section.

But estimating "uniqueness" of a visual signal is no easy task. It requires a very detailed model of our entire visual world, since only then we can know if something is truly unique. Therefore, instead we propose to compute uniqueness in a data-driven way—against a very large dataset of randomly selected images.

The basic idea behind our approach is that the features of an image that exhibit high "uniqueness" will also be the features that would best discriminate this image (the positive sample) against the rest of the data (the negative samples). That is, we are able to map the highly complex question of visual similarity into a fairly standard problem in discriminative learning. Given some suitable way of representing an image as a vector of features, the result of the discriminative learning is a set of weights on these features that provide for the best discrimination. We can then use these same weights to compute visual similarity.

To learn the "feature" weight vector which best discriminates an image from a large "background" dataset, we employ a method of supervised machine learning called a support vector machine, or SVM. For any given set of input data, an SVM predicts which of two possible classes forms the input. Specifically, we use a linear SVM, which can generalize even with a single positive example, provided that a very large amount of negative data is available to "constrain the solution."

In this case, the "negatives" are a dataset of images randomly sampled from a large Flickr collection, and there is no guarantee that some of them might not be very similar to the "positive" query image.

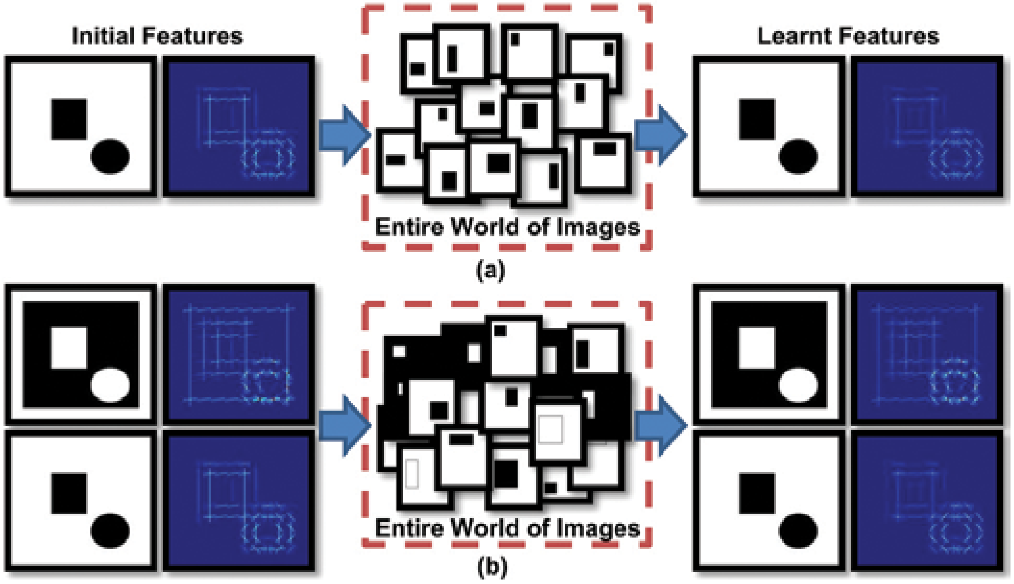


Figure 3

We begin by experimenting with simple, synthetic data. In our first experiment (Figure 3a), we use simple synthetic figures (a combination of circles and rectangles) as visual structures on the query image side. Our negative world consists of just rectangles of multiple sizes and aspect ratios. If everything works right, using the SVM-learned weights should downplay the features generated from the rectangle and increase the weights of features generated by the circle, since they are more unique.

One of the key requirements of our approach is that it should be able to extract visually important regions even when the images are from different visual domains. We consider this case in our next experiment, shown on Figure 3b. Here the set of negatives includes two domains—black-on-white rectangles and white-on-black rectangles. By having the negative set include both domains, our approach should downplay any domain-dependent idiosyncrasies both from the point of view of the query and target domains. Indeed, as Figure 3b shows, our approach was again able to extract the unique structures corresponding to circles while downplaying the gradients generated due to rectangles, in a domain-independent way.

We can also observe this effect on real images. The Venice bridge painting shown in Figure 4 initially has high gradients for building boundaries, the bridge and the boats. However, since similar building boundaries are quite common, they occur quite often in the randomly sampled negative images and hence, their weights are reduced.

Our framework should be able to work with any rigid grid-like image representation where the template captures feature distribution in a histogram of high-enough dimensionality. We also found that our notion of data-driven uniqueness works surprisingly well as a proxy for predicting

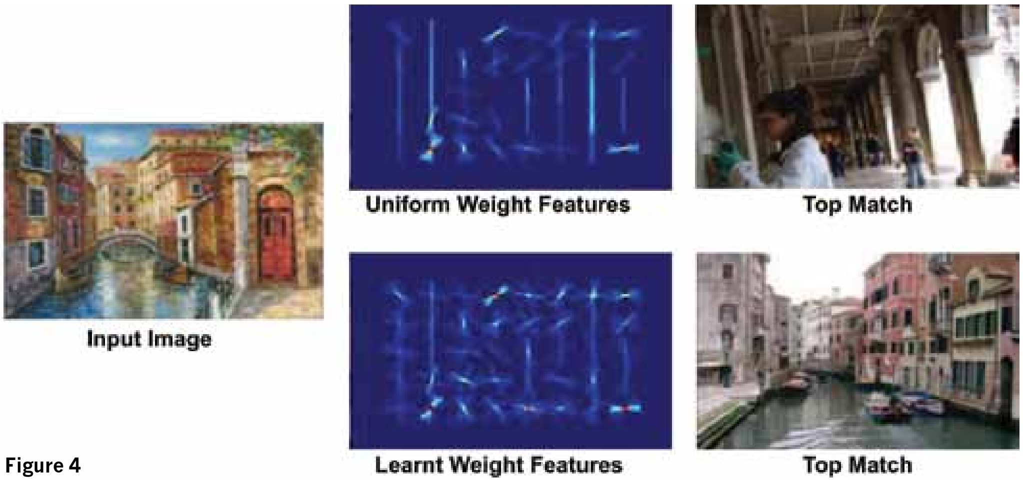


Figure 4

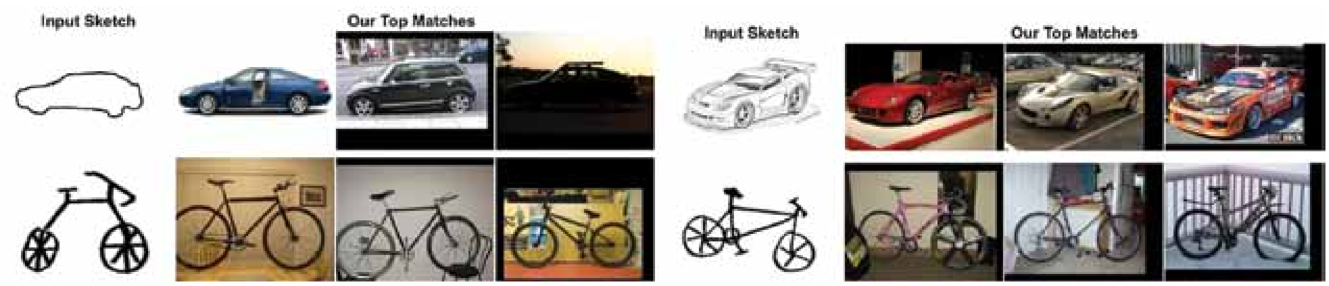


Figure 5a

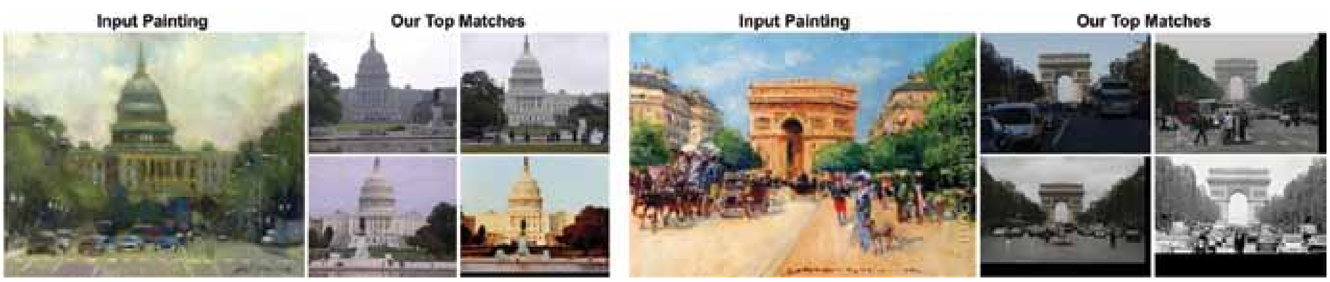


Figure 5b

image saliency ("where people look")—a topic of considerable interest to computer graphics.

Matching sketches to images is a difficult cross-domain visual similarity task. While most current approaches use specialized methods tailored to sketches, here we apply exactly the same procedure as before, without any changes. We collected a dataset of 50 sketches (25 cars and 25 bicycles) to be used as queries (our dataset includes both amateur sketches from the internet as well as freehand sketches collected from non-expert users). At this task (Figure 5a), our approach not only outperforms all of the other image retrieval methods we tested, but returns images showing the target object in a very similar pose and viewpoint as the query sketch.

As another cross-domain image matching evaluation, we measured the performance of our system on matching paintings to images (Figure 5b). Retrieving images similar to paintings is an extremely difficult problem because of the presence of strong local gradients due to brush strokes (even in the regions such as sky). For this experiment, we collected a dataset of 50 paintings of outdoor scenes in a diverse set of painting styles and geographical locations.

Applications

Our data-driven visual similarity measure can be used to improve many existing matching-based applications, as well as facilitate new ones:

- Matching the missing parts of images (scene completion)
- Matching new photographs to historic photographs
- Determining from which location a particular painting was painted
- Creating collections of visual scenes to be explored in a virtual world

The two main failure modes of our approach are illustrated in Figure 6. In the first example (left), we fail to find a good match due to the relatively small size of our dataset (10,000 images) compared to Google's billions of indexed images. In the second example (right), the query scene is so cluttered that it is difficult for any algorithm to decide which parts of the scene—the car, the people on sidewalk, the building in the background—it should focus on. Addressing this issue will require a deeper level of image understanding than is currently available.

Speed remains the central limitation of our approach, since it requires training an SVM at query time. While we developed a fast, parallelized implementation that takes under three minutes per query on a 200-node cluster, this is still too slow for many practical applications at this time. We are currently investigating ways of sharing the computation by precomputing some form of representation for the space of query images ahead of time.

However, even in its present form, we believe that the increased computational cost of our method is a small price to pay for the drastic improvements in quality of visual matching.

Alexei Efros is an associate professor of computer science and robotics at CMU, and Abhinav Gupta is an assistant research professor of robotics. Abhinav Shrivastava is a master's degree student in robotics. Tomasz Malisiewicz (CS'08,'11) is now a post-doctoral fellow at MIT.

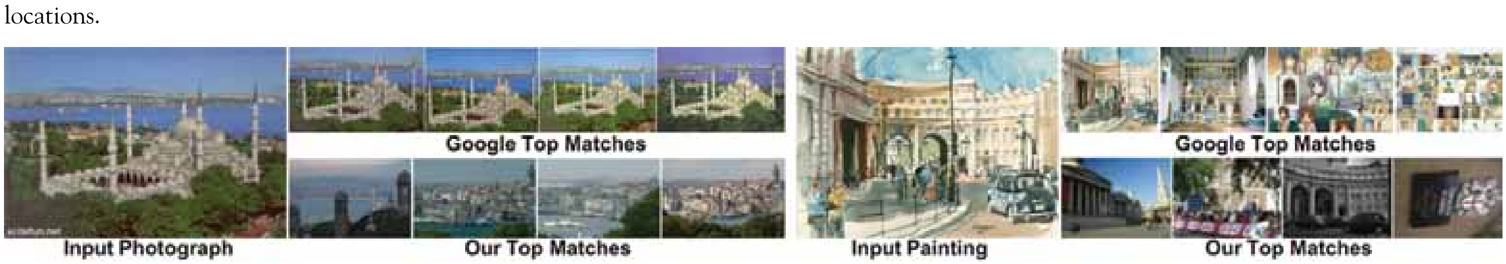


Figure 6

Tina M. Carr (HNZ'02)
Director of Alumni Relations
School of Computer Science
tcarr@cs.cmu.edu

Let's connect— not just online, but in real life

Hopefully you've had an opportunity to attend a recent SCS alumni event. They provide a great way for you to meet up with former classmates, make new connections (both socially and professionally), and to hear about the latest news and innovative research projects on campus.

While we certainly embrace social media and encourage you to connect with us via your platform of choice, face-to-face interactions at events are invaluable in fostering connections and helping to build a greater sense of community.

These gatherings also allow me (and our faculty members) to get to know you better! Personal time spent with alumni gives us a chance to hear your perspectives and feedback in a way that social media can't duplicate. It's always nice to put a face to a name (especially now that there are more than 6,000 of you!).

There are also a number of opportunities for SCS alumni to connect with the greater Carnegie Mellon alumni network by participating in university and regional alumni events.

For example, Carnegie Mellon Alumni Chapter events are a great way to meet other alumni in your region. Alumni chapters organize a variety of activities including faculty lectures, entrepreneurship panels, picnics, sporting events, cultural excursions and happy hours. Interested in helping organize events in your area? Become a volunteer. Alumni chapters depend on the dedication, energy and enthusiasm of the alumni volunteers. There are Carnegie Mellon Alumni Chapters around the world. Visit alumni.cmu.edu to see if there is one in your area.

Another way to meet up with fellow alumni is at Carnegie Mellon "Network Nights." Network Nights provide an informal forum for alumni who are hiring or job-hunting to make new connections, and give alumni the opportunity to meet with current students who are seeking internships and full-time positions in the region.

In mid-January, Network Nights took place in Boston, Silicon Valley and Seattle, during winter break.

Attendance at our Boston event was very good, with approximately 120 alumni. For the second year in a row, Zipcar hosted the event at its office in Cambridge. Then it was off to Network Night Silicon Valley (sponsored by Juniper Networks), where we greeted nearly 400 alumni and students. Both events were a wonderful mix of people—some from startups, some from more established companies.

Our third event, in Seattle, was at a new location—Boeing's Customer Experience Center, where they invite representatives of different airlines to view and tour mockups of jets currently under development. It was a wonderful venue and an enjoyable evening for 85 people.

We're well into planning events for this spring and summer. We'll have a big event for SCS and ECE alumni at Spring Carnival, and then we'll be on the road again to at least five (and maybe as many as eight) cities over the summer. Certain areas are a "given"—the San Francisco Bay area, Boston and Seattle for instance—we also hope to get back to San Diego and New York.

When they're here on campus, students in SCS and the Department of Electrical and Computer Engineering have a lot of interaction. Those interactions continue after school. (We have quite a few pairings between SCS and ECE alumni—in fact, there were several marriages this past summer!) Naturally, our summer events are held jointly between SCS and ECE.

If you want to know about alumni events in your part of the country being hosted by SCS, CMU or your particular regional alumni chapter, you have to make sure your contact information is up to date! Our email distributions are based on your current home address.

Also, if you were already registered in CMU's online alumni community (alumni.cmu.edu), you'll need to re-register. We don't maintain a separate SCS alumni database; instead, all alumni are incorporated into our university database.

CMU recently changed vendors for the alumni system, and the good news is that the new website is attractive, easy to use and offers a variety of new features—the bad news is you'll have to sign up for access, even if you'd signed up for the old database. (It only takes a minute, and it's free.)

You can use that database to update and edit your alumni directory information. If you don't want to sign up for the online community and you've moved or changed jobs recently, email me your updated contact information (tcarr@cs.cmu.edu) and I'll make sure to update it for you. Also, if you have any feedback or suggestions (like a great venue for an event), send me an email—feedback on The Link magazine is useful and appreciated, too.

Looking forward to seeing you online and (hopefully) in real life.

Tina M. Carr

Tina M. Carr (HNZ'02)

Director of Alumni Relations

School of Computer Science

(P.S.: Don't forget that we're on Facebook, Twitter and now Google+.)

Giving Back: The Impact of Philanthropy

> By Mark Dorgan

By now, most in the CMU community are aware of the amazing $265 million gift made by longtime university trustee Bill Dietrich, and of his passing on Oct. 6. The gift Mr. Dietrich made will have a significant impact on many generations of students and faculty. In 20 or 30 years, it will be interesting to hear from those who benefitted directly from this donation.

There are many in SCS who benefit from the generosity of our alumni and friends. We remain grateful to all of those who support programs in SCS, and we recognize the significant impact that this support has on individuals. Recently, I had the chance to talk with the recipients of two funds, Luis von Ahn (CS'03,'05), who holds the Nico Habermann Chair in Computer Science, and Brendan Meeder (CS'07), who holds the C. Gordon Bell Distinguished Graduate Fellowship in Computer Science, about what it means to them to be awarded these philanthropic honors.

The Habermann Chair was established in 1998 in memory of A. Nico Habermann, SCS's first dean and former head of the Computer Science Department, to support outstanding young faculty early in their careers. Von Ahn said that when he learned last year that he had been awarded the Habermann Chair, he found it both "meaningful" and "a great honor" to hold a chair named after a well-known, respected computer scientist credited with helping firmly establish SCS.

In the academic community, holding a named chair brings additional recognition both to a faculty member and their university. Chairs are "worth gold," von Ahn said, providing him with critical resources to help advance his research, and helping him recruit top graduate students to his group. While funds from various foundations or government agencies often come with spending limitations, having access to funds provided by the Habermann Chair gives von Ahn a reliable, flexible base of resources. The funds are used to purchase equipment for research and support travel to important conferences both for him and his graduate students.

Meeder, a fourth-year Ph.D. student in computer science, is in the first recipient of the C. Gordon Bell Fellowship. The Bell Fellowship was established with a gift from longtime CMU friend and former faculty member, Gordon Bell, currently a principal researcher at Microsoft Research. Bell received an honorary degree from SCS in 2010.

Brendan Meeder (CS'07) says that receiving the C. Gordon Bell Distinguished Graduate Fellowship in Computer Science was both "meaningful" and "a great honor."

Meeder said he was particularly honored to receive the Bell Fellowship, both because he was the first recipient and because he had attended lectures by Bell during an internship at Microsoft Research. Meeder, who was the first recipient of a teaching assistantship award while he was an undergraduate in SCS, said receiving the Bell Fellowship served as a vote of confidence in his work, which is something that's always useful for a graduate student to receive.

As alumni of SCS, both von Ahn and Meeder reflected on the significance and importance of alumni and friends philanthropic support of the school. As both of them have been touched by philanthropic support, they've also been donors in return. Both told me they feel it is incredibly important for alumni to give back.

For SCS to remain competitive and the top computer science program in the nation, von Ahn said, philanthropy is critical, particularly when considering the level of support many of our peer institutions receive. Meeder described philanthropy as the "fabric" of CMU. When walking around campus, he said, faculty, students and staff are constantly reminded of contributions of those who have had an impact on CMU—from Andrew Carnegie through Bill Dietrich, as well as Bill and Melinda Gates, Henry and Elsie Hillman, Ray and Stephanie Lane, David Tepper and many others.

Luis von Ahn and Brendan Meeder are just two of those in the SCS community who benefit from the generous philanthropic support of alumni and friends. Every day, directly or indirectly, everyone at CMU benefits from the benevolence and foresight of those who believe that giving to the university helps create a better world.

Many gifts have been made as a part of Carnegie Mellon's "Inspire Innovation" Campaign, which has now broken the $1 billion mark! Until June 30, 2013, you can still be a part of this historic milestone for CMU. To find out how you can help the School of Computer Science through scholarships, fellowships, faculty support or gifts to the Gates and Hillman Centers, please contact me at mdorgan@cmu.edu or call me at 412-268-8576. You can learn more about the Inspire Innovation campaign by visiting www.cmu.edu/campaign.

Mark Dorgan is executive director of major gifts and development liaison for SCS.


SUBMITTED PHOTO

Ting Shih

B.S., computer science, Carnegie Mellon University, 2001
M.S., information technology, Carnegie Mellon University, 2006
M.B.A., Massachusetts Institute of Technology, 2009
M.S., systems engineering, Massachusetts Institute of Technology, 2009

If there's a high-adrenaline sport, Ting Shih has either tried it or would like to. "Have you ever heard of Half Dome?" she asks. The granite mountain is located in the eastern part of California's Yosemite National Park. "I've climbed Half Dome," Shih says. "It's literally just a humongous rock." On parts of the mountain, climbers must hoist themselves up using a cable. It's a 45-degree incline, "but it feels like 70," she says. "If you let go, you fall." Her next obstacle? She's thinking about jumping from a stationary point while wearing a "wingsuit"—literally, a suit with wings—that allows the user to glide at speeds over 100 mph.

Shih takes risks in her career, too—the kinds of risks that pay off. Two years ago, the technology startup firm she helped launch broke up in a dispute among the co-founders. "I had to decide if I wanted to go find a corporate job, or try to continue with my mission and recruit a whole new team," Shih says. She struck out on her own path again. "I think I made the right choice," Shih says.

Shih's vision is delivering specialized health care at a fraction of the present cost. Doctors are in short supply in many underserved areas—and specialists of any kind are even fewer. On the other hand, it's common to find good quality mobile phone networks, even in remote areas without electricity. So Shih's company, ClickMedix, uses mobile devices to connect patients with doctors and specialists thousands of miles away. The company started with dermatology—80 to 90 percent of skin diseases can be diagnosed through photos and video, Shih says—and has since expanded into geriatric, maternity and pediatric care.

ClickMedix is now being used by specialists, primary care doctors, nurses, health workers and midwives in the Philippines, Trinidad, Guatemala, Uganda, India, Taiwan and the United States. The company generates revenue through license and subscription fees with health care providers, Shih says.

The intersection of health care and technology is fascinating, she says, because innovations have gratifying and instant results. Delivering care is "almost like writing a program," she says. "When you reduce errors and optimize health care delivery, you save lives."

Shih counts among her mentors SCS project scientist Phil Miller and Allan Fisher, former associate dean for undergraduate education, along with Lenore Blum, distinguished career professor of computer science, and Michael Murphy, former dean of student affairs who now serves as a CMU vice president. Miller, co-founder and executive vice president of iCarnegie Inc., now sits on the ClickMedix board of directors, while Blum's example has led Shih to try to mentor other young women interested in technology careers.

—Jason Togyer (HS'96)


SUBMITTED PHOTO

Bradley Nelson

B.S., mechanical engineering, University of Illinois at Urbana-Champaign, 1984
M.S., mechanical engineering, University of Minnesota, 1987
Ph.D., robotics, Carnegie Mellon University, 1995

Brad Nelson has heard all of the comparisons between his work and the classic science fiction film "Fantastic Voyage," about a tiny submarine that goes inside a human patient to perform surgery. Lately, from younger people, he's hearing about the movie "Innerspace," a 1987 film with a similar plot, but Nelson prefers the older film. "I guess I'm a Raquel Welch fan," he says, laughing.

But Nelson's work isn't fiction. It's fact. With his team at the Eidgenössische Technische Hochschule in Zurich, Nelson, a professor of robotics and intelligent systems, is doing research into microrobotics—tiny robots, invisible without a microscope, that can be injected into the eye with a standard needle. Once inside, external electromagnets are used to move the robots into position as researchers watch through an eye surgeon's microscope. Right now, Nelson's team is experimenting on animals, but within three years, he expects to be performing clinical human trials.

"One of the things we think we can help with is macular degeneration," says Nelson, founder of ETH's Institute of Robotics and Intelligent Systems. The disease destroys the center of the retina and can eventually leave its sufferers unable to read or recognize faces. Current therapies require injecting a drug into the eye and hoping it gets to the source of the problem. Nelson's robots can deliver drugs directly to the damaged areas. "We're also looking at how we can treat blockages in the retinal arteries," he says.

Other areas where such microrobots could perform medical procedures include the brain or spinal canal—any area where robots can move through fluid—but all of these ideas are "still really new," Nelson cautions. A more immediate application of the research being done by Nelson's team is likely to include improvements to the external manipulation of catheters inside blood vessels.

Last year, one of Nelson's robots won a world record as the smallest ever made. "You can publish in high impact journals, but when you hit the Guinness Book of World Records, that's when your nephews and nieces are really impressed," he says.

Early in his time at CMU, Nelson worked with Pradeep Khosla (now dean of CMU's College of Engineering) on larger, more conventional robots. "I kind of realized that a lot of research had already been done on robotic arms, and I wondered what kind of new research could be done," Nelson says. "I asked myself, 'What if we did all of this under microscopes, with tiny things?'" With large robots, researchers are concerned about gravity and friction, but with microrobots, their concerns are electrostatic and fluid forces, Nelson says. And rather than lathes and drill presses, researchers building microrobots use similar manufacturing processes to those that create silicon chips.

From Khosla, Nelson learned the value of hard work, and always "pushing a little deeper and thinking of the bigger impact" of ideas. "That's a good thing for a grad student to learn," he says. "When you're solving a problem, always look at it from a broader perspective."

—Jason Togyer (HS'96)

Stehlik receives Doherty Award

SCS ASSISTANT DEAN HEADED TO QATAR FOR FIVE-YEAR STINT

Mark Stehlik

Mark Stehlik, SCS assistant dean of undergraduate education, is the recipient of this year's Doherty Award for Sustained Contributions to Excellence in Education.

The honor comes at a pivotal time for Stehlik, who this summer begins a five-year stint as associate dean of education at Carnegie Mellon Qatar. He taught computer science at the Doha campus in 2006, 2007, 2008 and 2011, and organized its first annual high school programming contest.

Stehlik was involved in the Advanced Placement Computer Science course from its inception in 1984; has organized numerous training workshops for high school teachers; and co-authored "Running on Empty," a 2010 study of the nation's neglect of computer science education. In 1997, he won SCS's Herbert A. Simon Award for Teaching Excellence in Computer Science.

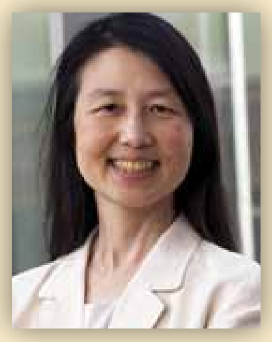
"Mark's gift is understanding people who love computer science," said Ian Ernest Voysey, an SCS staff teaching assistant. "He keeps the students roughly on their paths towards maturation, and he keeps the faculty united and roughly on their paths towards maturation. He does it all at high speed, with a grin on his face, and an open office door."

—Byron Spice

Blum, Veloso, Wing among 'famous women' of CS

Lenore Blum

Manuela Veloso



Jeannette Wing

Three faculty members in Carnegie Mellon's Computer Science Department—Lenore Blum, Manuela Veloso and Department Head Jeannette Wing—are among 55 women on the first list of "Famous Women in Computer Science" compiled by the Anita Borg Center for Women and Technology.

The list includes computer scientists who are technological pioneers, as well as those who are leaders or founders of technical companies, and who have achieved success and recognition beyond their home organizations.

The Borg Center, founded in 1997 as the Institute for Women in Technology by renowned computer scientist Anita Borg (1949-1983), is devoted to increasing the impact of women on all aspects of technology and to increasing the positive impact of technology on women of the world. Carnegie Mellon's Women@SCS was cited as a reference for the Borg list.

New workspace named for Kiesler, Kraut

A new collaborative workspace in Newell-Simon Hall has been named for Sara Kiesler and Bob Kraut. The announcement was made Dec. 2 by Justine Cassell, director of CMU's Human-Computer Interaction Institute, and came as a surprise to both Kraut and Kiesler, who were visibly moved by the tribute.

More than 50 of their former students donated to fund the renovations to the newly named Kiesler-Kraut Commons. The work was completed in Fall 2011.

Kiesler is CMU's Hillman Professor of Computer Science and Human-Computer Interaction, while Kraut is Herbert A. Simon Professor of Human-Computer Interaction.

Bob Kraut and Sara Kiesler examine the sign marking the new collaborative space named in their honor.

Two receive new Cooper-Siegel Professorships

Faculty members in SCS and CMU's College of Fine Arts are the first recipients of a pair of professorships for junior faculty that have been endowed by Eric Cooper, a Carnegie Mellon trustee and former computer science professor, and his wife, community volunteer Naomi Weisberg Siegel.

Eric Paulos, associate professor in SCS's Human-Computer Interaction Institute, will fill the first Cooper-Siegel Professorship of Computer Science, and Richard Pell, assistant professor of art, will hold the first Cooper-Siegel Professorship in Art.

Each professorship is for a three-year term and can be renewed once. After the initial terms, the professorships will alternate between disciplines—the professorship in CFA between faculty in art and music and the other between SCS faculty and the Mellon College of Science's physics faculty.

Eric Paulos

Paulos joined the Carnegie Mellon computer science faculty in 2008 and is the director of the Living Environments Lab, a collaborative research laboratory focusing on the intersection of human life, the living planet and technology. His areas of expertise span a deep body of research territory in urban computing, sustainability, green design, environmental awareness, social telepresence, robotics, physical computing, interaction design, persuasive technologies and intimate media.

Pell joined the CFA faculty in 2008 and teaches Electronic Media.

Cooper was a member of Carnegie Mellon's computer science faculty from 1985 to 1991. He served on the university's Board of Trustees from 1996 to 2002 and began another term on the board in 2010. After co-founding FORE Systems in 1990, he served as its CEO and then its chairman before the company's sale to Marconi in 1999. He has served as a director of several technology companies. He and Siegel, of Fox Chapel, are well-known philanthropists in the Pittsburgh area. Siegel is the daughter of two Carnegie Mellon alumni, musician Rebecca Weisberg Siegel and physicist Robert Ted Siegel.

Campus turns out for Zuckerberg visit

A rock-star-style welcome greeted Mark Zuckerberg, founder and CEO of Facebook, during his first visit to Carnegie Mellon University on Nov. 8.

After meeting privately with faculty and students, Zuckerberg gave a talk to an invitation-only audience. During brief remarks to the press, Zuckerberg, 27, said that his main reason for visiting the Pittsburgh campus was to recruit future employees. Mike Schroepfer, Facebook's vice president of engineering, accompanied Zuckerberg during the trip.

"We have a lot of Carnegie Mellon alums at Facebook and a lot of them are actually some of our best engineers," Zuckerberg said. "So when we decided to organize this trip to go see a few colleges, Carnegie Mellon was at the top of the list.

"Facebook looks for really entrepreneurial folks, people who are trying to have a big impact on the world and who have the ability to look at many of the hundred different problems at once and say, 'OK, this is the one that we really need to solve,'" he said.

Keck grant allows expansion of RNA game

EteRNA—a unique research project that taps online game play to create RNA designs that are then tested in a laboratory—is expanding, thanks to new support from the W.M. Keck Foundation.

A $1 million grant through the Keck Foundation's Medical Research Program will provide ongoing support for the year-old EteRNA project (see "It's All in the Game," Winter 2010 issue), which has already engaged more than 30,000 citizen-scientists in the study of RNA design.

The online game has identified a number of people, some without formal science training, who display a strong aptitude for RNA design and are generating important scientific insights. Biologists believe RNA molecules may be a key regulator of living cells.

Adrien Treuille, SCS assistant professor of computer science, leads the project with Rhiju Das, an assistant professor of biochemistry at Stanford University, and Jeehyung Lee, a CMU Ph.D. student in computer science.

The Keck Foundation support will help the researchers leverage advances in biotechnology that, Das says, "are leading to a radical re-imagining of the game."

As part of the Keck initiative, EteRNA is creating an advisory board of noted scientists, including Paul Berg, a Stanford biochemist and Nobel laureate in chemistry; Patrick O. Brown, also a Stanford biochemist; and David Baker, a biochemist at the University of Washington, to provide guidance as EteRNA explores this new way of conducting scientific research.

SCREEN SHOTS

CARNEGIE MELLON UNIVERSITY PHOTOS

Howie Choset, robotics professor; author Daniel Wilson; Jodi Forlizzi, associate professor of design and human-computer interaction; and Don Marinelli, executive producer of CMU's Entertainment Technology Center, during a Feb. 17 forum in Los Angeles.

How do Hollywood's robots stack up to Carnegie Mellon University's real-life innovations? Where's the line between fiction and reality?

These and other topics were addressed Feb. 17 at "Leading Innovation: Los Angeles and Beyond," which featured a panel of leading experts from CMU in the worlds of entertainment, artificial intelligence, robotics and technology.

"The field of robotics is moving so fast these days that it makes life tough for a sci-fi author. You come up with something new, only to find out it's already real," said Daniel Wilson (CS'03,'04,'05), who spoke on the panel.

Wilson is the author of How to Survive a Robot Uprising and Robopocalypse, which will soon be a Steven Spielberg film.

The event was planned as part of CMU's Inspire Innovation campaign, shining a spotlight on CMU faculty and alums who are paving the way in their fields.

"Robots have the potential to improve medical care by reducing costs, post-operative pain and stays in the hospital," said Howie Choset, a professor in CMU's Robotics Institute who spoke on the subject at the event.

Wilson and Choset were joined by Jodi Forlizzi, associate professor in the Human-Computer Interaction Institute and the School of Design.

Don Marinelli, executive producer and co-founder of CMU's Entertainment Technology Center, moderated the discussion.

The event came on the heels of the university's announcement that it has surpassed its $1 billion campaign goal with 16 months to go.

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ADDRESS CORRECTION REQUESTED

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Then and Now

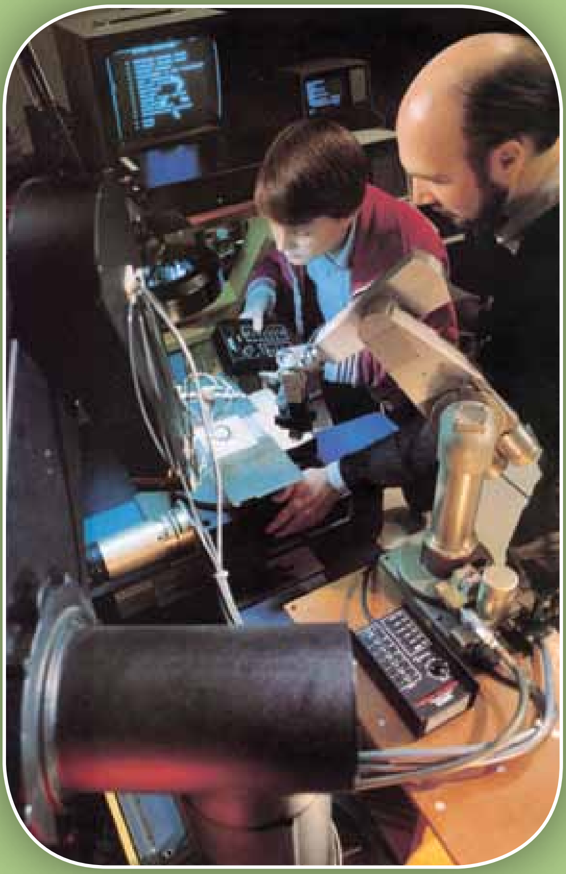
CMU's Robotics Institute was only a year old when a photographer for the former Westinghouse Electric Corp. took this picture for its annual report. It shows undergraduate student Jeff Bennett and Todd Simonds, then assistant director of the RI, working with a robotic arm that used both visual and tactile feedback to understand the orientation of parts being placed into a circuit board.

Westinghouse Electric executive Tom Murrin, who died Jan. 30, was instrumental in founding the Robotics Institute, shepherding $3 million in research funding from the Pittsburgh industrial conglomerate to Carnegie Mellon University. You can read more about his life on Page 8 of this issue.

Bennett (CS'82), who now lives in Ponte Vedra Beach, Fla., with his wife Jill and their three children, Abby, age 10, and twins Spencer and Sophie, aged 7, doesn't remember exactly what he and Simonds were doing that day, but does remember the photo. "Obviously, it was a little bit staged," says Bennett, who was recruited to work part-time in the new Robotics Institute by a friend, "Scott" Dyer (CS'81).

Six years later, Simonds co-founded RedZone Robotics along with William "Red" Whittaker (E'75,'79), the university's Fredkin Professor of Robotics and director of its Field Robotics Center. Simonds now serves as principal advisor to Concurrent Technologies Corp., a defense contractor based in Johnstown, Pa.

After graduation, Bennett worked for 10 years as a software engineer at the Florida-based electronics company Harris Corp. "It was great work, for which I was well prepared by my years at Carnegie Mellon," he says. And then he went in a different direction: Bennett became an ordained minister and earned his master's degree in theology at Atlanta's Emory University. ("The first time I stepped on campus, I said, 'Gee, I recognize these buildings!'" Bennett says. Emory's campus was designed by Henry Hornbostel, first dean of Carnegie Tech's College of Fine Arts and architect of many of CMU's original buildings.)



WESTINGHOUSE ELECTRIC CORP. PHOTO, VIA PENNSYLVANIA DEPARTMENT, CARNEGIE LIBRARY OF PITTSBURGH

These days, Bennett is lead pastor of Ponte Vedra United Methodist Church, with occasional stints as an Elvis Presley impersonator, singing The King's hits with new, Bible-themed lyrics. "I do it once a year for the church variety show, which seems to be plenty," Bennett says, with a laugh. "We used to call it a 'talent show,' but there was some question as to whether that was honest marketing." **—Jason Togyer (HS'96)**