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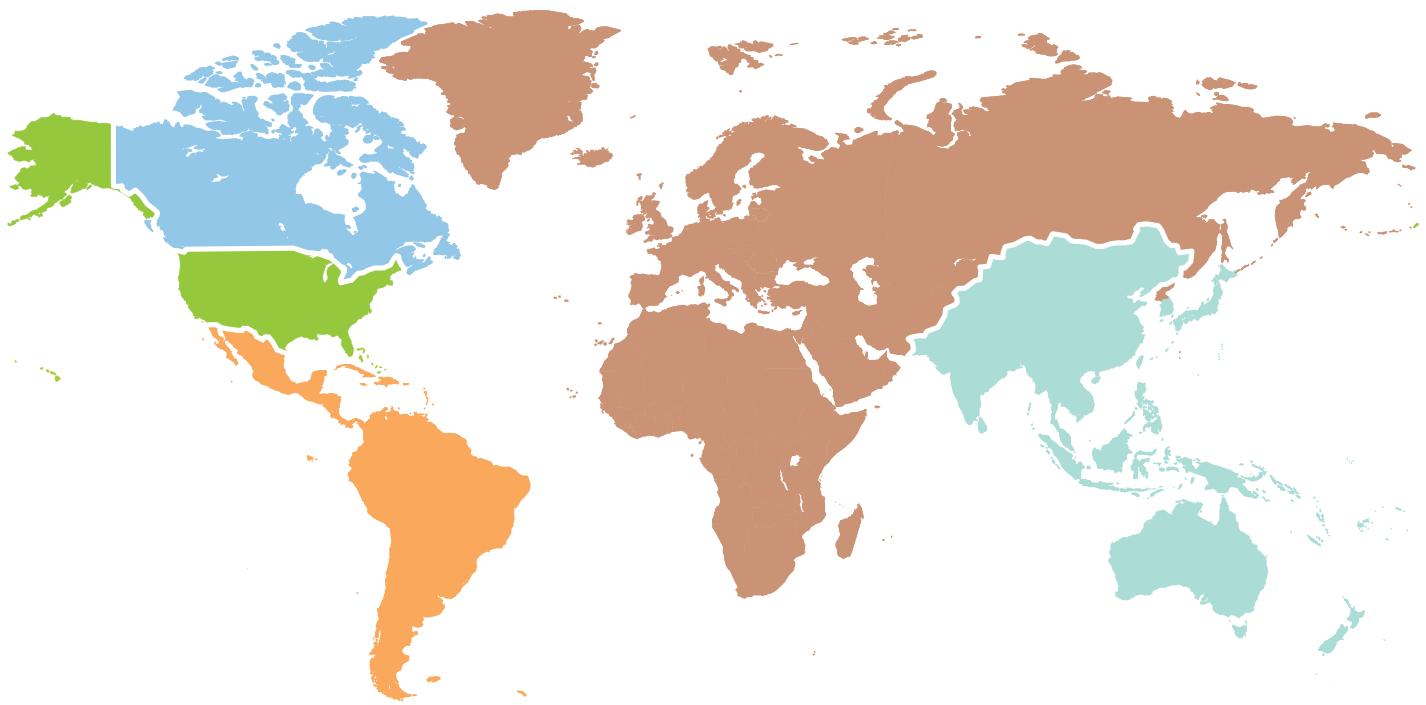- **Find** competitions and summer camps

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REGION NEWS

REGION 1

NORTHEASTERN UNITED STATES

■ **Boston Section** forms chapters of IEEE Industry Applications and IEEE Technology and Engineering Management societies.

■ **Long Island (N.Y.) Section** forms IEEE Systems Council chapter.

REGION 3

SOUTHEASTERN UNITED STATES

■ Student branch at the **University of Central Florida, Orlando,** forms IEEE Power & Energy Society chapter.

■ Student branch formed at **Kentucky State University, Frankfort.**

REGION 4

CENTRAL UNITED STATES

■ **Southern Minnesota Section** forms IEEE Life Members affinity group.

REGION 5

SOUTHWESTERN UNITED STATES

■ **Denver Section** forms IEEE Aerospace and Electronic Systems Society chapter.

■ Student branch at **Baylor University, Waco, Texas,** forms IEEE Microwave Theory and Techniques Society chapter.

REGION 6

WESTERN UNITED STATES

■ Student branch formed at **Chapman University, Orange, Calif.**

■ **San Francisco Section** forms IEEE Communications Society chapter.

■ **Hawaii Section** forms IEEE Power & Energy Society chapter.

REGION 7

CANADA

■ Student branch at the **University of New Brunswick, Fredericton,** forms IEEE Industry Applications Society chapter.

■ Student branch at **York University, Toronto,** forms IEEE Women in Engineering (WIE) affinity group.

REGION 8

EUROPE, MIDDLE EAST, AND AFRICA

■ **Bahrain Section** forms IEEE Communications Society chapter.

■ Student branch at **Czech Technical University, Prague,** forms IEEE Power & Energy Society chapter.

■ Student branch formed at **University of Bristol, England.**

■ Student branch at **University of Bordeaux, France,** forms IEEE Circuits and Systems Society chapter.

■ Student branch at **Otto von Guericke University, Magdeburg, Germany,** forms IEEE Engineering in Medicine and Biology Society chapter.

■ Student branch at the **University of Thessaly, Greece,** forms IEEE Power & Energy Society chapter.

■ Student branch formed at **Cork Institute of Technology, Ireland.**

■ **Italy Section** forms IEEE Information Theory Society chapter and IEEE WIE affinity group.

■ Student branch at **Jordan University of Science and Technology, Irbid,** forms IEEE Industry Applications Society chapter.

■ Student branch formed at **Ibn Tofail University, Kenitra, Morocco.**

■ **Oman Section** forms IEEE Communications Society chapter.

■ Student branch formed at **Lublin University of Technology, Poland.**

■ Student branch at **University of Aveiro, Portugal,** forms IEEE Circuits and Systems Society chapter.

■ Student branch at **University of Porto, Portugal,** forms IEEE Power & Energy Society chapter.

■ Student branches formed in Saudi Arabia at **University of Hail, Baqaa,** and **University of Tabuk.**

■ Student branch formed at **University of Alicante, Spain.**

■ Student branch at **National Engineering School of Monastir, Tunisia,** forms IEEE Engineering in Medicine and Biology Society chapter.

■ Student branches in Tunisia at **Ecole Nationale d'Ingénieurs de Sousse, National Institute of Applied Sciences and Technology,** and **Private University of Tunis** form IEEE WIE affinity groups.

■ Student branch at **Istanbul Medipol University** forms IEEE Engineering in Medicine and Biology Society chapter.

■ Student branch formed at **Istanbul Sehir University.**

■ Student branches formed in **United Arab Emirates** at **Amity University, Canadian University Dubai,** and **University of Dubai.**

REGION 9

LATIN AMERICA

■ Student branch at **Instituto Tecnológico de Buenos Aires** forms IEEE Engineering in Medicine and Biology Society chapter.

■ Student branch at the **National University of Tucumán, Argentina,** forms chapters of IEEE Computer, IEEE Power & Energy, and IEEE Industry Applications societies and IEEE WIE affinity group.

■ Student branch at **Universidad Nacional de San Luis, Argentina,** forms chapters of IEEE Industry Applications and IEEE Power & Energy societies.

■ Student branch at **Universidade de Brasília** forms IEEE Control Systems Society chapter.

■ Student branch at the **Federal University of Minas Gerais, Belo Horizonte, Brazil,** forms IEEE Industry Applications Society chapter.

■ Student branch formed at **Tecnológico de Costa Rica, Cartago,** forms IEEE Nuclear and Plasma Sciences Society chapter.

■ Student branch formed at the **Arts and Science University of Chiapas, Tuxtla Gutiérrez, Mexico.**

■ Student branch at **Pontificia Universidad Católica del Peru, Lima,** forms IEEE Aerospace and Electronic Systems Society chapter.

REGION 10

ASIA AND PACIFIC

■ Student branch at **Deakin University, Geelong, Australia,** forms IEEE Industry Applications Society chapter.

■ Student branches formed in **Bangladesh** at **Dhaka University of Engineering and Technology, Hajee Mohammad Danesh**

Science and Technology University, and Leading University.

■ Student branch at **International Islamic University, Chittagong, Bangladesh,** forms IEEE WIE affinity group.

■ **Beijing Section** forms IEEE Power & Energy Society chapter and IEEE WIE affinity group.

■ **Xian (China) Section** forms IEEE Geoscience and Remote Sensing Society chapter.

■ Student branch formed at **Guangdong University of Technology, Guangzhou, China.**

■ Student branch at **University of the South Pacific, Suva, Fiji,** forms IEEE Industry Applications Society chapter.

■ Student branches formed in **India** at **Baddi University of Emerging Science and Technology, G.H. Raisoni College of Engineering, KKR and KSR Institute of Technology and Sciences, Quantum School of Technology, University of Engineering and Management,** and **Vimal Jyothi Engineering College.**

■ Student branches in **India** at **G.H. Raisoni College of Engineering and Management, MES College of Engineering,** and **Sastra University** form IEEE Computer Society chapters.

■ Student branch at **Comsats Institute of Information Technology, Abbottabad, Pakistan,** forms IEEE Computer Society.

■ Student branches in **Pakistan** at **Punjab University, Lahore,** and **Fatima Jinnah Women University, Rawalpindi,** form IEEE WIE affinity groups.

BRIEFINGS

IEEE Strategy to Boost the Number of Engineers in Africa

TO ADDRESS THE shortage of engineers in Africa, IEEE's leaders have been meeting for the past several years with representatives from the continent's governments, universities, and industries, as well as with local IEEE members. Among the issues those sources raised were a lack of continuing education programs and the need for IEEE and other engineering associations to help develop appropriate public policy.

Based on those and other concerns, the IEEE ad hoc committee on activities in Africa—which serves as IEEE's representative on the continent—developed the Strategy for IEEE Assistance in Building Engineering Capacity in Underserved African Countries. It was endorsed in November by the IEEE Board of Directors and is now being implemented.

The strategy focuses on three goals: supporting engineering education and workforce development, serving as a resource to governments and other partners in developing standards and public policy, and building a sustainable community of IEEE members and volunteers. Africa has eight IEEE sections, six subsections, and more than 6,000 members from across the continent's 54 countries.

To learn more, read an interview with Senior Member Vincent Kaabunga, the ad hoc committee's chair, at http://theinstitute.ieee.org/blog/africa.

—*Kathy Pretz*

INSIDE

ONLINE

at theinstitute.ieee.org

IN MEMORIAM IEEE mourns the loss of three of its members.

MEMBERS IN THE NEWS Read about members who recently made headlines.

Annual Election Begins in August

LOOK FOR YOUR annual election ballot package to arrive in August via first-class mail with a postage-paid reply envelope. You'll also receive instructions by email explaining how you may access and return your ballot electronically.

Those eligible to vote include new members as of 30 June and students elevated to member or graduate student member grades on or before that date. Associate members are not eligible to vote.

To be eligible to vote, student members graduating this year between 1 January and 30 June must update their education information online to be elevated to member or graduate student member grade.

To become an IEEE member, you must be regularly employed in an IEEE-designated field and have a combination of education and work experience totaling at least six years. To apply for transfer to member grade, complete the online form at http://www.ieee.org/membership_services/membership/grade_elevation.html.

Log in to your IEEE account (http://www.ieee.org/profile) by 30 June and confirm or update your contact information, member communication preferences, and education information. That will help guarantee you receive your ballot package.

ELECTION DEADLINES

15 AUGUST
IEEE annual election ballots are mailed to voting members and electronic ballots are accessible.

2 OCTOBER
Last day that members' marked ballots will be accepted by IEEE, by noon CDT USA/17:00 UTC.

16 OCTOBER
Election results are announced by the IEEE Tellers Committee.

19–20 NOVEMBER
IEEE Board of Directors acts to accept the report of the Tellers Committee. Election results are made official.

IEEE Executive Director Is Retiring

AFTER ALMOST NINE YEARS of service, E. James Prendergast plans to leave the organization early next year.

Prendergast joined IEEE as executive director in 2009. Under his direction, IEEE has expanded its influence as a trusted voice in technology, developed standards that improve lives, and advanced science education. During his tenure, IEEE's global presence and engagement grew significantly, with the opening of offices in Bangalore, India, and Vienna and an expanded role in China, Japan, and Singapore.

Recently he oversaw the acquisition of IEEE GlobalSpec and its Engineering360 platform, a search engine and a leading source of news, data, and analytics for the engineering and technical community. The acquisition marked the first time that the not-for-profit professional organization acquired a for-profit company.

—Amanda Davis

Calendar
of Events

JUNE

5–6
IEEE 5G Summit, Honolulu

12–14
IEEE International Conference on Sensing, Communication, and Networking, San Diego

21–26
IEEE Meeting Series, New Brunswick, N.J.

JULY

3–7
IEEE Conference on Network Softwarization, Bologna, Italy

13–15
IEEE Women in Engineering Summit, Goa, India

25–28
IEEE Nanotechnology Conference, Pittsburgh

23–26
IEEE International Conference on Smart Grid and Smart Cities, Singapore

AUGUST

11
IEEE Region 2, 4, 8, and 10 meetings, Sydney

11–13
IEEE Sections Congress, Sydney

15
IEEE annual election ballots are mailed to voting members and electronic ballots are accessible.

ENGINEERING AN ACCESSIBLE WORLD

Assistive Robots for Independent Living

IEEE members build technologies to help people with disabilities accomplish everyday tasks BY **AMANDA DAVIS**

A PPROXIMATELY 15 PERCENT of people around the world—some 1 billion in all—have a disability, according to the World Bank.

The U.S. Census Bureau says 1 in 5 people in the United States will be 65 or older by 2030. And 20 percent of Japan's population is already 65 or older. Many elderly people will develop conditions that affect their hearing and vision.

In this issue, we feature several IEEE members who are developing technologies that can help people who are blind, deaf, or have limited physical mobility.

IEEE Senior Member Siddhartha Srinivasa, founder of the Personal Robotics Institute at Carnegie Mellon University, in Pittsburgh, is working on robots [like the one above] to help people with paralysis live independently. And IEEE Fellow Rory Cooper, a military veteran who suffered a spinal cord injury, has developed a robotic wheelchair that can give people a smooth ride over uneven terrain [see article, right].

Another member, Juan Aceros, is leading the Adaptive Toy Project at the University of North Florida, in Jacksonville, to retrofit drivable miniature cars and make them accessible to kids with disabilities [p. 9]. And we present three life-changing technologies that were on display at this year's Assistive Technology Conference, in San Diego [p. 8].

To help you stay abreast of what's going on in the fields of accessible and assistive technology, we also rounded up IEEE resources including conferences, publications, and standards [pp. 15 and 16].

We feature IEEE Member Angelo Quattrociocchi, CTO of 3DPhotoWorks, a startup that's creating tactile 3-D versions of classic paintings for museums so that blind people can experience artworks through touch [p. 17]. And we profile IEEE Member Conor Walsh, who designed a soft, robotic exosuit to help stroke patients and others to walk with less difficulty [p. 18].

In Karen Bartleson's president's column, she discusses how IEEE is addressing the ethical implications of technology, including quandaries posed by artificial intelligence and autonomous systems [p. 13]. And don't miss our Q&A with the 2018 IEEE president-elect candidates, Fellow Vincenzo Piuri and Life Fellow Jacek M. Zurada [p. 10].

Visit theinstitute.ieee.org for our latest content. To comment on what you've read in this issue, email the editors: institute@ieee.org.
—Amanda Davis, senior editorial assistant

I MAGINE IF THE ACTIVITIES you enjoy and perhaps take for granted—such as cooking a meal and eating it with your family, or exploring the outdoors—became difficult or even impossible because you had a physical or cognitive disability.

Two IEEE members are working on assistive robotics to let people with disabilities maintain a sense of independence while accomplishing everyday tasks they no longer can do on their own.

HELP AT HOME

Senior Member Siddhartha Srinivasa is founder of the Personal Robotics Lab at Carnegie Mellon University, in Pittsburgh. He's leaving CMU this month to join the University of Washington, Seattle, where he will continue to build devices to help people with mobility issues because of spinal cord injuries or aging.

When caregivers aren't available to help someone with limited mobility 24 hours a day, technology can step in. But Srinivasa doesn't want his robots only doing things for people; he wants them to work *with* humans, he says, to achieve a goal, like preparing a meal.

He and other researchers at CMU started working on HERB (home-exploring research butler) more than a decade ago. The two-armed, three-wheeled robot stands about 2 meters high and helps people with paralysis

Left: A researcher at Carnegie Mellon University's Personal Robotics Lab tests out the ADA, a robotic arm that can help feed people who are paralyzed. Above: IEEE Fellow Rory Cooper demonstrates the MEBot robotic wheelchair, which can climb curbs and navigate uneven terrain. Right, from top: HERB, a robotic butler at CMU's Personal Robotics Lab, can perform tasks such as microwaving meals and manipulating small objects.
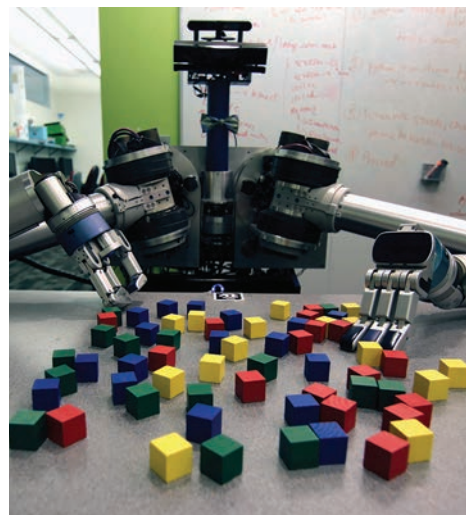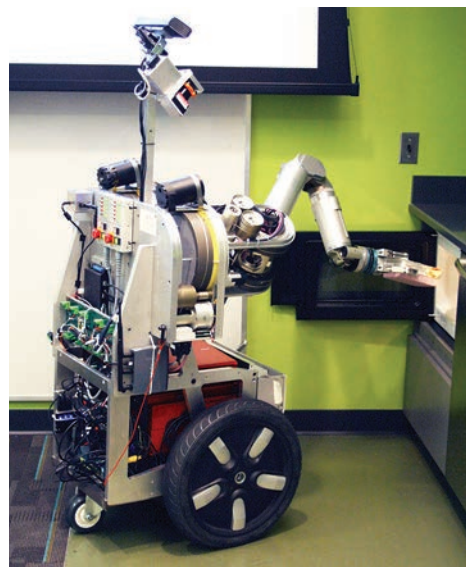
perform simple tasks around the home. It can, for example, unload a dishwasher or prepare simple meals.

With an object-detecting Kinect camera for a head, HERB relies on image-analysis software to find things, such as a piece of fruit or a microwaveable meal. It then grasps the object (each of its hands has three multi-jointed fingers). RGBD sensors process red, green, and blue color information as well as depth—so HERB can figure out the distance to an object.

In the process, the robot can determine the optimal way to move its limbs without accidentally bumping into something. For now, HERB is used only for research; it won't be in homes anytime soon.

Another of Srinivasa's projects is the Assistive Dexterous Arm (ADA—an acronym chosen to honor computing pioneer Ada Lovelace). The portable, flexible arm, with two mechanical fingers, weighs less than 10 kilograms [photo, opposite page]. Clipped to a wheelchair or table, it can help feed people unable to grasp utensils on their own.

Srinivasa says the ADA is learning several more things: how to ladle hot soup, for example, twirl spaghetti on a fork, and cut meat. And timing is important, he notes: The ADA needs to read social cues to determine when to dole out the next bite of food. A person eating with a friend doesn't necessarily

take a bite right after swallowing the last one. The next bite might come only after she has stopped speaking, or when her companion briefly looks away. The team is still working on algorithms to determine the right time to serve up the next spoonful or forkful of food.

GETTING AROUND

Living independently at home is great, but people with disabilities don't necessarily want to be inside all day. IEEE Fellow Rory Cooper [above, left] has been working for decades on designing autonomous wheelchairs and attachments to help people explore the world in ways previously thought impossible.

Cooper is director of the Human Engineering Research Laboratories (HERL), a joint effort of the University of Pittsburgh and the U.S. Department of Veterans Affairs. Thirty percent of the faculty and student researchers at HERL have a disability. In 1980 while serving as a U.S. Army sergeant in Worms, Germany, he sustained a spinal-cord injury in a bicycle accident that left him partially paralyzed.

He and other HERL researchers recently developed the Mobility Enhancement Robotic Wheelchair (MEBot), which can handle rugged terrain yet is narrow enough to cruise through doorways and down hallways. The researchers were challenged to build the chair by the U.S. Marine Corps Wounded Warrior Regiment.

The MEBot has six wheels—two large drive wheels (about 35 centimeters in diameter) in the middle and four caster wheels: two in front and two in back. When the wheelchair senses a curb, the front casters lift onto it, followed by the drive wheels. It's a smooth climb that doesn't jostle the passenger. When the wheelchair goes up a ramp, sensors detect the incline and adjust the seat to keep it level. The chair can navigate slippery surfaces, where traditional power wheelchairs sometimes get stuck or spin their wheels. The ultimate goal is for the MEBot to climb a flight of stairs, Cooper says.

Cooper also invented the PARA (patient assist robotic arm), and he is working with RE2 Robotics, a Pittsburgh startup, to bring it to market. The PARA attaches to the edge of a standard power wheelchair's seat and can help people transfer from the chair to a car, toilet, or couch. People who use wheelchairs can have trouble transferring out of them unless the destination is near the same height and only a few centimeters away.

The PARA can lift a person who weighs up to 113 kilograms and handle the transfer over greater distances. Hooks on the arm attach to a sling, which supports the person being lifted. The team recently was awarded a US $75,000 grant from the U.S. National Institutes of Health to develop a commercial prototype, which is still a few years away from completion.

"We are working to give people with severe disabilities from spinal cord injuries or ALS [amyotrophic lateral sclerosis] a level of mobility that is simply unprecedented," Cooper says. ◆

A blind woman [left] connects with an Aira representative [below], who can see her surroundings in real time via a camera on the woman's smartglasses. The representative can talk her through tasks such as finding a restaurant and reading a menu.

Three Life-Changing Innovations for People With Disabilities

Assistive technology conference features a variety of new gadgets BY **AMANDA DAVIS**

MORE THAN A billion people around the world have some sort of disability, and it's important to create technologies to help them. That was the idea behind many of the technologies on display at the CSUN (California State University, Northridge) Assistive Technology Conference, held from 1 to 3 March in San Diego. Here are three of the more impressive devices.

ASSISTANT FOR THE BLIND

Say you're walking to meet a friend at a restaurant, and the normal route you take is blocked by construction. A sighted person could navigate around the obstacle, but if you're blind, your task is much more difficult.

That's where Aira, a remote personal assistant service, could come in handy. Aira customers receive a pair of smartglasses equipped with a microphone and camera. They get help from a human assistant sitting sometimes hundreds of kilometers away. The camera feeds the Aira representative a view of the wearer's surroundings. If help is needed, the wearer can simply tap a button on the glasses to contact the representative, who uses a laptop to connect with the person's camera.

Once connected, the representative can describe the surroundings to the wearer, track her location on a map, and guide her through city streets and transit systems. Representatives also can help with everyday tasks, like grocery shopping, reading restaurant menus, and picking out clothing. Erich Manser, who is legally blind and an expert on accessibility technologies for the blind, said at the conference that he sometimes asks Aira representatives to give him the play-by-play of his daughter's soccer games.

Customers of the San Diego–based startup can subscribe to Aira for a set number of minutes each month (with the company promising its representatives won't disconnect when the customer runs out of minutes). Monthly plans range from US $89 to $329. Along with the smartglasses, customers receive an AT&T personal Mi-Fi device that helps them connect to the Internet wherever they are. The smartglasses can be paired with the customer's earbuds or headphones.

A STEADY SPOON

A simple task such as eating a bowl of soup can be a messy ordeal for people whose hands shake uncontrollably due to essential tremor or Parkinson's disease. That's what motivated a startup in South San Francisco, Calif., to design the Liftware Steady, a utensil handle with sensors and motors that cancel out a customer's tremor and cut down on spills. The startup, originally called Lift Labs, was acquired by Google in 2014 and is now part of Verily Life Sciences.

Sensors in the Liftware Steady handle detect hand motions, and its small computer distinguishes an involuntary tremor from the intended movement of the hand. Three attachments are available: a tablespoon, a soup spoon, and a fork. To stabilize the utensil and hold it steady, the computer directs two motors in the handle to move the attachment in the direction opposite to a detected tremor. The handle, with a charger and a spoon attachment, is $195. The soup spoon and fork are $35 each.

In December the company released the Liftware Level, which allows people with mobility issues from, for example, cerebral palsy to hold a spoon or other utensil at any angle without spilling its contents.

The batteries for both devices lasts for at least an hour of continuous use on a single charge, and the attachments are dishwasher-safe.

In December an anonymous donor gave 24 of the devices to Ability Now, an organization in Oakland, Calif., that provides assistive technologies and support services to people in the Bay Area with developmental and physical disabilities. Thanks to the high-tech utensil, one recipient told Verily that she has for the first time in years felt comfortable enough to eat Christmas dinner in the same room as her family.

VISUALIZING SOUND

It's not just startups producing assistive technologies. Microsoft, through its Garage incubator program, is developing Hearing AI, a smartphone app for the deaf and hard of hearing. The app, which interprets sounds through artificial intelligence, vibrates when the alarm on a smoke detector or carbon monoxide detector goes off. Another feature applies deep learning to convert speech to text, and vice versa, making it easier for the user to communicate with the hearing world.
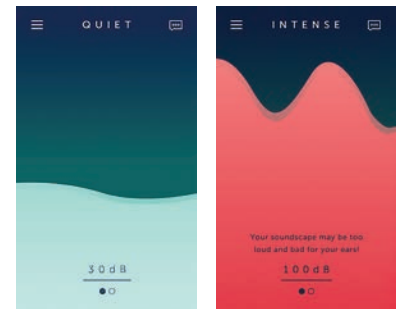
The Microsoft Hearing AI app's colorful animations can convey the level of noise in a room to people who are deaf.

The app also uses augmented reality to help people visualize the sounds around them. Users simply hold their smartphone up to what they see before them and see animations overlaid on the scene. The animation will pulsate, for example, to the rhythm of a pop song playing in the room.

The app, still being tested, is so far available only for iOS smartphones. ◆

Transforming Toys for Kids With Special Needs

IEEE student members work with physical therapists to build tailor-made cars BY **KATHY PRETZ**

KIDS LOVE driving battery-powered toy cars and playing with interactive stuffed toys that have buttons and switches, but some children have disabilities that make it difficult to engage in such play. The Adaptive Toy Project at the University of North Florida, in Jacksonville, is working to change that.

The project involves a semester-long elective course that teaches the school's physical-therapy and mechanical and electrical engineering students—including several IEEE student members—how to adapt toys with off-the-shelf components. The result is accessible toys for half the price of similar custom models on the market. IEEE Member Juan Aceros, an assistant professor of engineering at the school, helped develop the course and now teaches it.

Not only can the toys improve children's lives, but the program also teaches engineering students how they can make a difference. So far, 87 engineering students have taken the course.

HELPING HANDS

Aceros and Mary Lundy, a professor of physical therapy at UNF, launched the project as a pilot in 2014. Their idea was to offer an elective course to engineering and physical therapy students who would work together converting ride-on cars and interactive toys for children with disabilities. Schools, hospitals, and physical therapy programs in the area identify kids who need help.

The Eunice Kennedy Shriver National Institute of Child Health and Human Development of the U.S. National Institutes of Health awarded the project a five-year grant last year. That and donations from others cover the cost of the toys, the components to adapt them, and other materials.

About 25 students during the fall semester work with the children's doctors to assess their needs, sit in on their physical therapy sessions, and visit the children's homes. That process can take up to two months, Aceros says. Then the teams get to work at the university's lab, which is equipped with 3-D printers as well as power and hand tools including plenty of soldering irons.

Each semester, Aceros and Lundy focus on different types of disabilities. The teachers have addressed cerebral palsy, Down syndrome, quadriplegia, and other conditions.

From September to December last year, the teams customized ride-on cars and small toys with switches and buttons for children with cortical visual impairments. CVIs are the fastest-growing cause of visual impairment for children ages 1 to 3 in developed countries. The condition is caused by a defect in the brain's visual cortex. According to Aceros, children with a CVI have trouble with visual signals and might require an object to move in order to see it properly. The kids can perceive color, but they gravitate toward simple objects with only one color.

A senior who took the course in the fall, IEEE Student Member Andrew Bliss, came up with the idea of applying line-follower technology so the car steers itself. Sensors he mounted beneath the car detect the contrast between black tape on the floor and the floor's lighter background.

A button 15 centimeters in diameter replaced the car's steering wheel. When the driver hits the button, the motorized car moves forward and follows the line of black tape. The car has an Arduino microcontroller and a Sabertooth motor controller. The Arduino acts as the brains, collecting data from the sensors. The Sabertooth provides the power to drive the toy's electric motors. PVC panels with soft padding were added to support the child's legs and head. A seatbelt keeps the child restrained and offers trunk support.

"Put the tape down in the child's home and he can drive his car around the house along the tape without crashing into anything," Aceros says.

About 35 toys have been given away to children who participated in the project.

"Low-income families can't afford to buy them in a store," Aceros says. If sold in specialty stores, adapted ride-on cars would retail for triple the amount of a regular car, which at national chain stores costs as much as US $240.

In the class, engineering students also teach physical therapy students how to adapt the small switch toys using a few wires and a connector for a little less than $10, Aceros says.

THE HUMAN SIDE

"Engineering students know how to build things, but the human aspect is not in the curriculum," Aceros says. "We want them to develop skills not typically taught in the classroom and put them in situations they are unfamiliar with and where they have to think outside the box. I don't tell them what to build. They have to come up with their own ideas for modifying the toys by working with the physical therapists as well as the children."

IEEE Student Member Ayshka Rodriguez, a first-year EE graduate student, has been with the program since its start. Today she assists new students in the class.

"I signed up because I'm interested in biomedical applications, and through the program, I discovered a love for human anatomy," Rodriguez says. "I now have a better understanding of how assistive devices can affect children or anyone with physical disabilities."

Bliss says he took the course because he craved experience in building things.

"I wanted to learn how to use microcontrollers, motor controllers, and sensors," he says. "But the class also taught me how to collaborate with others, to express ideas that were complex to students of other disciplines, and to take a child's feedback and implement that in a design."

It also taught him about what it means to help others.

"When we delivered our first adapted toy car," he says, "seeing that smile on the kid's face and hearing his laughter felt so good!" ◆

Top: A visually impaired child takes his toy car for a spin. The car follows a line of black tape, making it easier for children with disabilities to drive. Above: Jason Pavich [left], Chris Martin [center], and Garrett Baumann are three of the students at the University of North Florida who helped modify the cars as part of the school's Adaptive Toy Project.

Get to Know the Candidates for 2018 IEEE President-Elect

Vincenzo Piuri and Jacek M. Zurada discuss their priorities for the organization

BY **MONICA ROZENFELD**

THE ANNUAL IEEE election process begins in August, so be sure to check your mailbox then for your ballot. To help you choose the 2018 IEEE president-elect, we interviewed the two candidates, IEEE Fellow Vincenzo Piuri and IEEE Life Fellow Jacek M. Zurada, about their priorities and how they would improve IEEE's products and services.

Piuri is a professor of intelligent systems and former chair of the information technology department at the University of Milan, as well as an honorary professor at three other universities. His interests include intelligent systems, machine learning, neural networks, pattern recognition, signal and image processing, and digital architectures. He coauthored four books and founded a startup focused on intelligent systems for industrial applications.

Elevated to Fellow in 2001 for "contributions to neural network techniques and embedded digital architectures for industrial applications," he is a member of IEEE–Eta Kappa Nu, the organization's honor society. He was 2015 vice president of IEEE Technical Activities, IEEE Division X director/delegate from 2010 to 2012, and president of the IEEE Computational Intelligence Society in 2006 and 2007.

He has been editor in chief of the *IEEE Systems Journal* since 2013, and he has served on the IEEE Publication Services and Products and IEEE Technical Activities boards as well as on several IEEE committees.

Zurada is director of the Computational Intelligence Laboratory at the University of Louisville, in Kentucky, where he is a professor of electrical and computer engineering and former chair of the department. His work focuses on computational intelligence, machine learning, and image and signal processing. He has served as a consultant to industry and to startups. Zurada has also authored or coauthored three books including the textbook *Introduction to Artificial Neural Systems*. His research has been cited more than 10,000 times.

Elevated to Fellow in 1996 "for contributions to engineering education in the area of neural networks," he was elected a foreign member of the Polish Academy of Sciences and has been awarded five honorary professorships.

Zurada was 2014 vice president, IEEE Technical Activities, and president of the IEEE Computational Intelligence Society in 2004 and 2005. He was editor in chief of the *IEEE Transactions on Neural Networks* from 1998 to 2003 and chaired the IEEE Technical Activities Board (TAB) periodicals committee in 2010 and 2011.

What would be your top two priorities as IEEE president?

PIURI: My first priority is to nurture both the IEEE members and the scientific and professional community at large. I plan to continue providing high-quality resources, particularly on emerging technologies, as well as specialized topics.

I will promote personalized services and specialized networking opportunities that provide practical knowledge, especially for industry professionals and entrepreneurs. I'll also further support IEEE Young Professionals and IEEE Women in Engineering. I would like to provide more value to members by offering affordable and sustainable dues to help those in underserved groups and geographic areas as well. I would also expand our cooperation with national associations, and enhance IEEE's global support for developing public policies and services.

My second priority is to promote cooperation among all IEEE groups as "One IEEE." I would do so by creating synergies within IEEE, promoting a culture that values diversity, and expanding micro-volunteering opportunities, which allow members to dedicate their services in small increments of time. I would reinforce management and financial transparency to members and ensure full participation and representation of IEEE members and volunteers in decision-making processes.

ZURADA: My first priority will be to better respond to the needs of industry practitioners. Our products, services, and educational offerings have to be more relevant to their jobs and career aspirations.

I will focus on providing members in industry with information through topically organized industry resource centers. Such centers will offer a single point of entry and will help users find quality technical information quickly. They will also allow practioners to continue their education and their lifelong career growth. In concert, I will

RICK OLIVIER

Vincenzo Piuri [left] and Jacek M. Zurada

IEEE must continue to be the trusted source of high-quality knowledge, and facilitate the sharing of data and algorithms for research, bolstering its reputation as the hub for exchanging and publishing ideas, and networking with experts. We should promote interaction between academia and industry. Real-world problems can stimulate academics, and their results can advance industry.

IEEE should also increase educational material and syllabi, including on topics such as engineering ethics, social implications of technology, standards development, and sustainable technology. These will not only facilitate the activities of members in academia but contribute to educating the future generation of engineers and have a wider impact on industry and society as well.

How has living in Europe helped shape your view of engineering? How could IEEE better serve members in different geographic regions?

PIURI: Engineering is an attitude of mind, from detecting a problem to deploying and maintaining its solution. This is the same all over the world. However, local cultures provide unique perspectives and richness.

My experience and institutional roles have given me the good fortune of interacting with academics, professionals, and students from different geographic regions, understanding and appreciating their varied needs and perspectives. I grew up in and live in Italy, but I have also spent several periods working on my research and collaborating with people in the United States, Canada, and countries throughout Europe, North Africa, Asia, Oceania, and South America. I am also the coordinator of computer science/electrical engineering international academic exchanges for my university—which finds me interacting with colleagues and students from different continents.

IEEE can better serve members and the scientific and professional communities by respecting and appreciating diversity, and identifying—with the help of local IEEE groups and other organizations—sustainable products and services designed for each area.

ZURADA: My experience with moving from Europe to the United States in the 1980s demonstrated that there is *one* engineering profession, no matter where you go. Since we all speak the same language, my transition from the Swiss Federal Institute of Technology, Zurich, to the University of Louisville went smoothly.

Furthermore, working for three years in Asia exposed me to non-Western cultures and taught me that the global diversity of IEEE is one of its most powerful assets. IEEE offers a common platform to contribute to the profession and to help members advance their careers regardless of their address.

Having said this, I will strive to provide equal opportunity to current and future members from underprivileged and underrepresented groups. This includes women, students, and young professionals, and those who aspire for professional growth in less advanced economies.

Ethical concerns are being raised about artificial intelligence, a field in which both of you work. What role should IEEE play to ensure ethical considerations are part of its development?

ZURADA: Ethical concerns in AI are quickly gaining importance due to its rapid growth. Progress in AI is bringing increasing societal benefits in human-computer interaction, transportation, and robotics and intelligent systems. As AI becomes entwined in the fabric of life with applications in smart homes, health care, social services, and the environment, the public expectation is that these technologies will be secure, safe, and transparent.

As an important contributor to AI-based technologies, IEEE must be a key player in this area. Last year, IEEE launched its Ethically Aligned Design report, and I'm very supportive of its initial document. As president, I will embrace and champion its recommendations.

PIURI: Technology pervades our daily life, providing us with conveniences but also raising ethical concerns. This applies not only to AI but also to other technical areas.

IEEE should strongly promote awareness of these concerns to the general public and encourage educators to make ethics a part of university curricula as well as include it in continuing education and preuniversity programs. We

work toward greater engagement of industry in IEEE.

My other priority will be to continually gauge and respond to *all* members' needs. This includes delivery of affordable and high-quality products and services, like journals, magazines, conferences, and industry portals. While IEEE nurtures emerging technical areas and builds communities around them, it needs to offer more career resources for members, who must keep up with advancing technology and maintain their competitiveness in a rapidly evolving career ecosystem.

From your experience as a college professor, how do you think IEEE can better support members in academia?

ZURADA: With more than 4 million documents in the IEEE Xplore Digital Library, our members in academia need better, more intelligent tools to retrieve more than just articles, titles, and abstracts. Supplying our IP users with knowledge offers more value than supplying them with traditionally formatted information. Our members would benefit from productivity tools that use data analytics and are able to answer a technical question or recommend a design or algorithm to fit their specifications. While this goal may appear somewhat distant, it's important to realize that five years ago we could not make inquiries with a smartphone and get instant answers as we do today. I will lead IEEE in the direction of offering better search tools for research and design.

Our members in academia would also benefit from quick information exchanges, especially in emerging technologies. As we nurture communities working in new technical areas, IEEE needs to continue to expand our support for sharing technical information and for networking. This includes facilitating inexpensive Web-based workshops and conferences.

PIURI: IEEE should provide more services for research and education.

must also promote ethics-by-design methodologies, support professionals in industry and government on the subject of ethical considerations, and increase standards activities in this area. IEEE should be the reference point for policymakers on ethics in our technical fields.

Each of you has served as editor in chief of an IEEE publication and has written numerous articles. How can IEEE better assist editors and authors?

PIURI: IEEE can better support editors by continuing to improve the system for manuscript management, facilitating simpler navigation tools, and enriching automatic support for choosing reviewers—which will help editors select reviewers based on their credentials. We must also further improve anti-plagiarism tools.

To support authors, recommendation tools should be introduced to identify relevant IEEE literature. And we need to improve data and algorithm repositories supporting experimentation and comparisons, language-proofing services, and journal-impact analyses.

ZURADA: IEEE's periodicals are considered a hallmark of technical excellence. I feel privileged to have served as an editor in chief of one of our transactions and later as chair of three committees: transactions, periodicals, and periodicals review. Our authors and readers justifiably expect a shorter submission-to-publication time.

Realizing these needs, as vice president of IEEE Technical Activities, I launched the "Train the Trainer" workshops aimed at continuous recruitment and training of reviewers and associate editors. In addition, if elected president, I will work with editors on publishing reproducible research that connects to data repositories. I will also promote editorial policies that increase article relevance for industry practi-

tioners and embrace nontraditional works dealing with the impact of technology on society.

Why did you join IEEE? What has been your most memorable moment as a member of the organization?

ZURADA: I joined IEEE more than 30 years ago because of my fascination with the profession. My membership opened up abundant opportunities for participation in conferences and publishing, and engaging with societies and boards. All of this has encouraged me to continue to contribute. I want to give back to the profession that has given me so much.

Volunteering for IEEE has afforded me many memorable experiences, because I have always felt the trust, collegiality, and professionalism of the organization. One of my favorite events

Zurada

is the annual IEEE Honors Ceremony, which validates the societal impact of the technologies we champion. The ceremony highlights the ways in which we touch people's lives as we advance technology for humanity.

PIURI: I learned about IEEE from my academic supervisor when I was

Piuri

pursuing my master's degree, and volunteered to help with a conference she was organizing. I liked feeling part of and serving the community. As tired as I was after running around the whole day taking care of logistical problems, I was proud to be part of what was taking place.

The enthusiasm, service, and participation of IEEE volunteers are what first attracted me. The contributions of every member make IEEE what it is. While earning my Ph.D., I began to appreciate IEEE as the premier forum for research and its dissemination, and for developing applications for technology.

Since then, I have served in many volunteer capacities, always with the same enthusiasm of that first day. Many moments have been memorable, but those that have been particularly rewarding are ones in which I felt I could make a difference by providing better service to our community.

Why should members vote for you?

PIURI: I will focus on nurturing IEEE members and our scientific and professional community, and I will promote a holistic vision for "One IEEE."

I feel that I have the technical background, academic and industrial experience, management and leadership skills, genuine global

perspective, and deep and broad understanding of IEEE activities and operations to lead our efforts in this direction. I also will work to increase visibility of the organization worldwide.

I have a positive attitude, with the ability to listen to people, valuing and respecting those from all backgrounds. I care for those in underserved groups and geographic areas. And I will focus on the needs of all individuals, catalyzing members' efforts and aspirations, stimulating cooperation and full participation in decision-making processes, and working in a collegial way to achieve consensus. I will also strongly promote transparency and trust.

I envision an IEEE where everyone in our global scientific and professional community finds more value and wants to be a proud member of an organization in which they are nurtured and appreciated.

ZURADA: IEEE is a multifaceted, global organization that needs a president with a unique set of leadership, technical vision, and people skills. As a Life Fellow who has held top IEEE leadership positions on three major boards, chaired six TAB committees, and been a society president, I believe I have the vision, knowledge, and experience to take the leading role. I communicate well, form partnerships, and support innovation.

I had multicultural exposure in my educational upbringing in Poland and Switzerland, followed by my 30-year professional career in the United States. I spent sabbaticals at Princeton and leading universities in Hong Kong, Japan, and Singapore. In addition to English, I speak Polish, German, French, and Russian.

This experience has significantly shaped my outlook and given me the confidence and skills to be an effective leader of the increasingly global IEEE.

To learn more about the candidates, visit their websites: vincenzopiuri.org and jacekzurada.org.

Ethical Implications of Disruptive Technologies

IEEE initiative focuses on artificial intelligence and autonomous systems

KAREN BARTLESON IEEE PRESIDENT AND CEO

ETHICS AND technology are not new areas for IEEE. Our commitment to advancing technology to benefit humanity—via ethical behavior among those working within IEEE fields of interest—has guided us and our predecessor societies since the early days of their formation. We adopted our first code of ethics more than 100 years ago, in 1914. The IEEE Society on Social Implications of Technology has been bringing together experts in professional ethics and in ethics applied to the technology design process for more than 45 years through conferences, publications, and special initiatives.

However, with the ongoing development of powerful technologies and disruptive innovations such as artificial intelligence and autonomous systems (AI/AS) comes the need for greater social responsibility and accountability from the technology community. Hence, many IEEE fields, and engineering in general, are beginning to consider ethics like never before.

There is no doubt that AI is transforming how we work, play, and think in revolutionary ways. Recent developments in AI-focused areas herald its full-fledged arrival via autonomous automobiles, cognitive computing, and collaborative robotics. Like any disruptive innovation, AI presents a number of complex public policy challenges in terms of our moral values and ethical principles that require extensive knowledge of science and technology for effective decision-making. These issues span a diverse spectrum of applications including agriculture, communications, energy, the environment, health care, and transportation.

IEEE is already working to prioritize the maximum benefit to humanity and the natural environment, while mitigating the risks and negative impact as AI/AS evolve as socio-technical systems. IEEE members are leading efforts to integrate ethical considerations into the design of these innovations in several ways: by bringing together leaders within the fields of ethics and AI; by sharing expertise, perspectives, and ideas at conferences and workshops; by engaging in international, consensus-based standards development; and by fostering collaboration at all levels of inquiry and initiative.

The IEEE Global Initiative for Ethical Considerations in Artificial Intelligence and Autonomous Systems brings together multiple voices in the AI/AS communities to advance a public discussion of how these intelligent and autonomous technologies can be aligned to moral values and ethical principles that prioritize human well-being. The purpose of this initiative is to ensure every technologist is educated, trained, and empowered to prioritize ethical considerations in the design and development of AI/AS technologies.

Under the Global Initiative, the "Ethically Aligned Design: A Vision for Prioritizing Human Wellbeing with Artificial Intelligence and Autonomous Systems" document was released late last year. This impactful document provides insights and recommendations from more than 100 global thought leaders in academia, science, government, and corporate sectors in the fields of AI, ethics, philosophy, and policy. It provides a key reference to AI/AS technologists as they prioritize value-driven, ethically aligned design in their work.

In addition, numerous standards projects inspired by this initiative have been launched. These include IEEE P7000: Model Process for Addressing Ethical Concerns During System Design, IEEE P7001: Transparency of Autonomous Systems, and IEEE P7002: Data Privacy Process.

Articles about these and other efforts appeared in May on *The Institute's* website (http://theinstitute. ieee.org/tag/ethics).

With powerful innovations comes the need for greater social responsibility from the technology community

AN ETHICAL LENS

IEEE responds to key emerging technologies through its Future Directions initiatives. In addition to exploring a technology itself, each of these initiatives also considers ethics and policy issues where applicable. For example, IEEE's Brain Initiative is anticipating the ethical aspects of advances in brain-machine interfaces, as well as facilitating collaboration to advance research, standardization, and development of technologies in neuroscience to help improve the human condition. Much of the work of our Robotics and Automation Society includes an examination of the ethical implications in this critical area of technical innovation.

The work being done by the IEEE Global Initiative, Future Directions, and other IEEE committees contributes to a broad effort being advanced at IEEE to foster an open, expansive, and inclusive conversation about ethics in technology, known as the IEEE TechEthics program. Launched last year, the program aims to coordinate and drive institute-wide activities in technology ethics and to showcase IEEE as a thought leader in conversations about the ethical and societal impacts of technology.

IEEE TechEthics hosted a technical session in August at The Hague. "Conversations on Ethical and Social Implications of Artificial Intelligence" attracted an international audience from disciplines including technology, ethics, law, policy, and philosophy. The program has also begun to establish partnerships with other organizations. A series of virtual sessions and another international event are in the works.

We will continue to work to coordinate and create IEEE-wide synergies among ongoing and emerging initiatives. We want to address a widespread ethics landscape—from developing professional guidelines to assessing societal impacts to considering technological implementation. And we will continue to advocate for technologies that benefit humankind around the globe.

Please share your thoughts with me at president@ieee.org. ◆

TJ KLEIN

Sparking Conversation

Readers commented on our March special issue on 5G as well as several articles on our website. These included a blog entry about how changes to U.S. immigration policy and H-1B visas could affect engineering worldwide and another on whether automation is likely to kill or create jobs.

Commenters also weighed in on increasing diversity in the workplace and whether women are holding themselves back in their careers by not pushing for leadership roles.

IS 5G SAFE?

The issue on 5G networks was all about going full speed ahead with the new technology and all the possibilities 5G could bring. I was alarmed there was not a single mention of any potential health risks of this new microwave technology. There are plenty of early reports regarding the potential negative effects of 5G, which is based on higher-frequency microwave radiation. I know it's nonionizing radiation, and that the radiation may turn out to be a nonissue, but it is alarming that *The Institute* would neglect to even mention the technology's possible health risks.

—*Dean Miller*

IMPACT OF H-1B

I wonder how the development of AC power and other electrical technologies would have gone if Nikola Tesla had not been able to immigrate to the United States. How would research programs at major U.S. universities, corporations, and government laboratories fare without engineers who are immigrants?

—*Kelly Manning*

The main purpose of giving students from developing countries the chance to study in the United States should be to equip them with the tools necessary to improve the lives of the people in their home country. The continued "brain drain" from the developing world to the United States is in no one's best interest. It undermines development in the poorer parts of the world, and it undermines our long-term security through increasing inequality.

There is no shortage of U.S. scientists and engineers. A hundred applicants for an open position in this country requiring a Ph.D. in physics or engineering is not uncommon, and an open position for a software engineer can easily attract twice that many applicants from the United States.

It is time for U.S. universities to take a look at their business models and decide if they are operating for the benefit of humanity, or simply for their own profit.

—*Young*

U.S. universities want international students to enroll so they can increase their revenue. Companies want H-1B workers because they can hire engineers for a much lower salary and have them shackled to their positions because they cannot easily switch to another company. Mid-career engineers in the 1970s (when I started) made as much as mid-career physicians, but the compensation and working conditions of engineers have decreased markedly.

From my perspective as an engineer and manager for 44 years, the entire system needs an overhaul. H-1B is necessary but misused.

—*Leatherstocking*

AN AUTOMATED FUTURE

Robots will not replace workers completely, but they will alter a company's decision on whether to hire another person. To justify hiring one more worker, companies need to consider whether the additional income and profit generated by the new employee exceeds the person's salary. The same applies to buying automated machinery—will the increased income and profit exceed the cost of purchasing and running the machine?

If a machine can be programmed to perform the task and do it more cheaply, or for longer periods of time, it alters the outcome of the equation. The more tasks a machine can do, the more possibilities for productivity. People who can program a machine to do something or prepare it mechanically or electrically to perform the task become far more valuable than ones who can simply do the task themselves.

—*facefurney2*

When the Luddites sabotaged early power looms in England in the early 1800s, they could not imagine that most people would want more than one shirt. People who believe that automation will lead to unemployment simply lack imagination.

There are enormous unmet needs and wants that increased productivity will help satisfy. We could build a transportation system that gets us coast to coast in under two hours. We could personalize information generation and delivery. Most young children could have a stay-at-home parent instead of forcing them to go to day care. And there could be more time for family, recreation, and the arts.

—*George Reeves*

ALPHA FEMALE

At a recent IEEE Women in Engineering conference I went to, attendees said they had to learn how to push themselves forward and were given more opportunities once they made it known that they were seeking additional responsibilities.

—*Thayla Rae*

I disagree that women will succeed if they are just more assertive in the workplace. Push hard as a female and you are dinged for "bad behavior." If we really have a diverse workplace, then there shouldn't be one (white male) cultural norm for success.

—*Maggie*

WORKPLACE DIVERSITY

Frankly, I don't give a damn about diversity. I have nothing against it and have certainly worked with and for people of other races, religions, and sexual orientations. I approve of nondiscrimination policies, but I'm in favor of hiring the best people for the job, whoever they are. Diversity for diversity's sake is not a worthy criterion.

—*Gordon Apple*

ISTOCKPHOTO

BENEFITS

Conferences Address Innovations to Improve Quality of Life

Upcoming events feature rehabilitation robots and brain-machine interfaces

IEEE Biomedical Circuits and Systems Conference

TURIN, ITALY; 19–21 OCTOBER

TOPICS: Assistive, rehabilitation, and quality-of-life technologies; brain-machine interfaces; biosensors; implantable electronics; lab-on-chips; medical information systems; biomedical image processing; and biofeedback systems.

SPONSORS: IEEE Circuits and Systems, IEEE Engineering in Medicine and Biology, and IEEE Solid-State Circuits societies
VISIT: http://biocas2017.org

■ **International Conference of the IEEE Engineering in Medicine and Biology Society**
JEJU ISLAND, SOUTH KOREA; 11–15 JULY

TOPICS: Neuromuscular and rehabilitation systems, wearable biomedical sensors, biomedical signal and image processing, cellular and tissue engineering, drug-delivery systems, neural engineering, and surgical robotics.
SPONSOR: IEEE Engineering in Medicine and Biology Society
VISIT: http://embc.embs.org/2017

ISTOCKPHOTO

■ **International Conference on Computer and Applications**
DUBAI; 6–7 SEPTEMBER

TOPICS: Assistive technology, intelligent transportation, e-health, biomedical sensors, haptics, cloud computing, information security, robotics, embedded systems, big data, virtual reality, and natural-language processing.
SPONSORS: IEEE United Arab Emirates Section, Springer
VISIT: http://www.ijcis.info/icca17.htm

■ **IEEE/Robotics Society of Japan International Conference on Intelligent Robots and Systems**
VANCOUVER, B.C., CANADA; 24–28 SEPTEMBER

TOPICS: Assistive and medical robots, robotics for physical rehabilitation, robot companions, automation applications for health care, autonomous vehicles, brain-machine interfaces, computer vision, deep learning, manipulation for robotic prosthetics, and haptic interfaces.
SPONSORS: IEEE Industrial Electronics and IEEE Robotics and Automation societies, Robotics Society of Japan
VISIT: http://www.iros2017.org

■ **IEEE International Conference on Systems, Man, and Cybernetics**
BANFF, ALTA., CANADA; 5–8 OCTOBER

TOPICS: Assistive technology, user interface design, neural networks, machine learning, human-computer interaction, virtual and augmented reality systems, decision support systems, smart metering, intelligent transportation systems, smart sensor networks, and wearable computing.
SPONSOR: IEEE Systems, Man, and Cybernetics Society
VISIT: http://www.smc2017.org

IEEE Member Hugh Herr, an associate professor of biomechatronics at MIT, developed prosthetic feet that allow him not only to walk but also to rock climb. He talks about his work on bionic limbs in an IEEE.tv video, "Extreme Bionics: The End of Disability."

All About Assistive Technology

BY **AMANDA DAVIS**

ENGINEERS ARE developing robots, tools, and prosthetics to help people with disabilities explore the world around them. IEEE resources to get members up to speed include videos, publications, and standards.

VIDEOS

Several IEEE.tv videos are on assistive tech. "Accessing the Future" presents interviews with engineers and industry experts on the role technology plays in the lives of individuals with disabilities that include visual and hearing impairments, learning difficulties, and paralysis.

Also check out "Extreme Bionics: The End of Disability," in which IEEE Member Hugh Herr [above] of the MIT Media Lab talks about his work on bionic limbs that mimic and enhance movement. Herr, an associate professor of biomechatronics, had his legs amputated from the knees down because of severe frostbite suffered during an ice-climbing trip in New Hampshire. He developed prosthetic feet that allow him to hike and rock climb at a more advanced level than was possible even before the amputation.

PUBLICATIONS

In January, *IEEE Potentials* magazine published a special issue called "The Hope of Assistive Technology." It included articles on intelligent robotic wheelchairs, prosthetic legs, and tactile diagrams for the blind. The magazine, published six times a year, is mailed to IEEE student members.

Healthcare Technology Letters is an open-access journal that appears four to six times per year and frequently offers articles on assistive tech. In March, for example, it published "Pervasive Assistant Technology for People with Dementia" and "Disrupting the World of Disability: The Next Generation of Assistive Technologies and Rehabilitation Practices."

Also in March, the quarterly *IEEE Robotics and Automation Magazine*, from the IEEE Robotics and Automation Society, featured "The Soft Robotics Toolkit: Strategies for Overcoming Obstacles to the Wide Dissemination of Soft-Robotic Hardware." Soft robots, made of lightweight, wearable textiles, help people with mobility issues [see p. 18]. The society plans to publish a special issue this year on assistive robotics.

TECHNICAL COMMITTEES

Members can join the IEEE Robotics and Automation Society's technical committee on wearable robotics, which focuses on human-machine interaction and wearable devices for physical rehabilitation. The society's technical committee on soft robotics explores lightweight wearables that can help people with limited mobility grasp and manipulate objects, navigate rough terrain, and perform other tasks. You can find the committees on the society's website: http://www.ieee-ras.org.

The technical committee on haptics, founded by the IEEE Computer and IEEE Robotics and Automation societies, has conferences, publications, workshops, and tutorials on haptics—the science of applying tactile sensation and control to robotic devices and computer applications. Researchers in this area have developed prosthetics that can restore the sense of touch for people who have lost hands and arms. You can find more information at the committee's website: http://www.worldhaptics.org.

Two technical committees of the IEEE Systems, Man, and Cybernetics Society are involved with assistive technology. The brain-machine interface systems committee aims to help people with a prosthetic limb perform certain tasks. The virtual interface between the brain and the prosthetic mimics the way that able-bodied people see, hear, walk, and grasp an object.

There is also the society's technical committee on companion technology, which promotes the development of robotic systems that sense and adapt to people's needs, preferences, and emotions. The committee is organizing the IEEE International Conference on Companion Technology, to be held from 11 to 13 September, in Ulm, Germany. For more information about both committees, visit the society's website: http://www.ieeesmc.org.

STANDARDS

The IEEE P1622.5 Standard for Election Systems Usability and Accessibility spells out ways to evaluate voting systems to ensure they are accessible to people with disabilities. Such voting systems include election administration and management, as well as vote-capture and tabulation devices that provide information to voters, poll workers, and election officials. The standard defines best practices for user-interface and interaction design, describes accessibility and universal design standards, and examines workflow and user needs.

The IEEE P2650 Standard for Enabling Mobile Device Platforms to Be Used as Prescreening Audiometric Systems establishes the performance, interoperability, and validation requirements of such systems for the hearing impaired. The platforms typically consist of a mobile phone, a portable or wearable device, and their software. For more information, visit http://standards.ieee.org. ◆

Making Art More Accessible to the Blind

Printing technology helps people visualize images through touch

BY **MONICA ROZENFELD**

IF YOU'VE EVER seen a Leonardo di Vinci masterpiece or a photography exhibit, you can understand how images are able to transform your perspective of the world. But the blind and the visually impaired cannot experience art in the same way. That's why one IEEE member has developed a technology to help bridge that gap.

As CTO of the startup 3DPhotoWorks, in Chatham, N.Y., Angelo Quattrociocchi invented a system that can print paintings and photographs on wood, high-density polyurethane foam, and other materials. People can touch the artwork and feel its shapes and textures—not necessarily textures that were in the original artwork but ones that now provide a tactile way of "seeing" the art.

The company, which got its start in 2008, has displayed its tactile art in the Canadian Museum for Human Rights, in Winnipeg, Manitoba, as part of the Sight Unseen: International Photography by Blind Artists exhibition. The art for Sight Unseen was created by artists with varying degrees of visual impairment. 3DPhotoWorks created the prints so that visitors could feel what's in the images, such as a photo of a hand reaching out to touch a woman's face.

The company is working on installations for five colleges and museums including the Museum of the American Revolution, which opened in April in Philadelphia.

The startup employs 10 people and says it is breaking even. With interest picking up from museums and educational institutions, though, the company says it expects to be profitable in the next couple of years.

Some of the artworks incorporate infrared sensors that, when touched, provide audio from speakers or headphones with additional information about each piece.

Blind and visually impaired visitors to museums are typically escorted by docents, who describe the images to them. However, as visitor Deanna Ng said in a video about the Sight Unseen exhibit, "When others describe art to you, it's from their experience and not your own. [With tactile art] I can interact with the art and create my own image in my mind."

THE ART OF SEEING

The startup is the brainchild of photographer John Olson, who says he wanted to help blind people experience visual art. Olson began his career as a war photographer at age 21, and was the youngest photographer ever hired to the staff of *Life* magazine.

Museums hire 3DPhotoWorks to give tactile surfaces to artworks in their collection. However, the company converted Van Gogh's *Portrait of Dr. Gachet* and Emanuel Leutze's *Washington Crossing the Delaware* to tactile art as proof-of-concept pieces.

To create the tactile art, Olson hired Quattrociocchi, who was designing digital printers at the time. Quattrociocchi created a printer for the startup that could provide tactile details "down to the brushstroke."

A graphic designer replicates a painting's brushstrokes on a computer program. When printed, the brushstrokes are several millimeters deep—large enough to be felt.

Quattrociocchi essentially reengineered a large inkjet printer to add more depth and detail. The company holds multiple patents for the technology.

The first part of the printing process requires a bit of manual work. A high-resolution, color-perfect copy of the original artwork is first uploaded to a computer. Then, a 3-D conversion specialist augments the piece by digitally adding depth so the art appears three-dimensional. For a portrait, for example, facial features become more sculpted and contoured.

The updated 2-D file is then printed at a size of 150 by 300 centimeters, at depths of up to 50 mm. Most printers allow for depths to only 5 mm.

Based on feedback from those who have touched the works, the team learned that people are more sensitive to textures than to shapes. Textures provide stronger mental images, so Quattrociocchi is working on adding greater texture to his pieces.
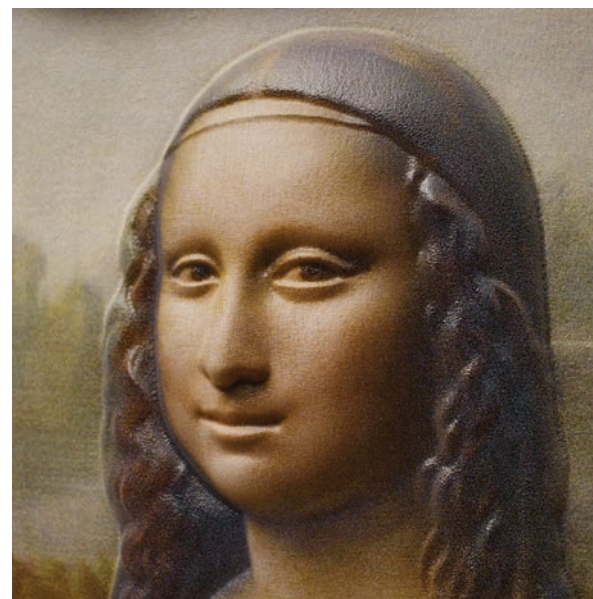
By transforming 2-D artworks such as the Mona Lisa *and* Washington Crossing the Delaware *into 3-D tactile images, 3DPhotoWorks allows people who are blind or visually impaired, like the child above, to experience art through their sense of touch.*

The works might be more vivid for those who became blind or visually impaired later in life—they're able to recall colors and objects they've seen before. However, the works also can help those born blind to "see" art for the first time.

ACCESS FOR ALL

Why does 3DPhotoWorks make its tactile art pieces in color? The exhibits are for sighted people, too, Quattrociocchi notes. They also can experience the art by feeling it. And most legally blind people have some degree of vision, however slight, he adds.

The company hopes to work with science centers and zoos in the coming years, helping students learn about science, technology, engineering, and math through touch.

The original idea for the company was to develop artwork that people could buy to hang in their homes, but the process has proven too expensive. As Quattrociocchi continues to automate his approach, however, he hopes the art will become more affordable. ◆

If you started a company and are interested in being featured in one of our upcoming issues, email the editors: institute@ieee.org.
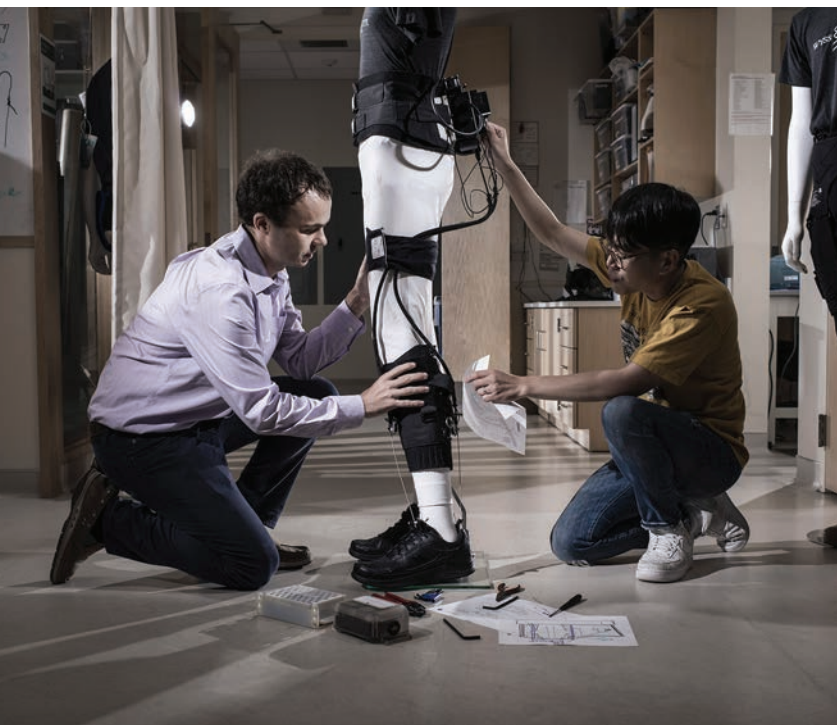
IEEE Member Conor Walsh [left] and Jaehyun Bae, a Ph.D. student at Harvard's Biodesign Lab, work on building a lightweight exosuit, which supports a wearer's movement with every step.

Conor Walsh: Designer of the Soft Robotic Exosuit

The invention can help stroke survivors walk

BY **KATHY PRETZ**

WHAT BEGAN as a program for the U.S. Defense Advanced Research Projects Agency to help soldiers carry heavy packs with less effort led IEEE Member Conor Walsh [above, left] and his group at Harvard to design a lightweight exosuit for stroke patients and those with weakened leg joints.

Walsh, an associate professor at Harvard's John A. Paulson School of Engineering and Applied Sciences, also teaches at the university's Wyss Institute for Biologically Inspired Engineering. And he founded Harvard's Biodesign Lab, which brings together researchers from different disciplines.

The exosuit is a wearable robot made of soft, lightweight textiles, with cables and motors that target leg joints, training the patient to walk normally.

Walsh recently was honored for his work on the exosuit. He received the 2017 IEEE Robotics and Auto-mation Society Early Career Award. Walsh, who is 35, was cited "for contributions to soft robotics and wearable technology for rehabilitation."

He is coauthor of "Multi-Joint Soft Exosuit for Gait Assistance," published in the proceedings of the 2015 IEEE International Conference on Robotics and Automation, available in the IEEE Xplore Digital Library.

The Institute interviewed him about the exosuit and his efforts to encourage students to get involved in wearable robotics.

What inspired you to design a wearable robot?

I worked on rigid exoskeletons as a graduate student at MIT with Professor Hugh Herr, an IEEE member, and learned a lot about robotics and human locomotion. After having his legs amputated due to frostbite, Herr, an associate professor of biomechatronics, developed prosthetic feet [see p. 16].

MIT is where I also first learned about the challenges of adding extra weight to a person and aligning human joints with an exoskeleton's joints.

How did the soft exosuit come about?

Starting at Harvard in 2012, I was inspired by colleagues working with silicone, plastic, and soft materials to make soft robotics. We began developing the exosuit with the goal of helping healthy people walk with less effort.

In 2014 we started exploring the possibility of adapting the technology for stroke patients. A stroke can impact gait when it causes the person to drag the affected leg. The soft exosuit can help propel the wearer forward; it lifts his feet and keeps his toes from turning down so that they don't drag on the ground and cause him to stumble. The concept was first presented at the 2015 IEEE International Conference on Rehabilitation Robotics.

How does the exosuit work?

The soft exosuit transmits assistive torques to the wearer's ankle joints without relying on rigid external structures. Motors, pulleys, and a battery pack are carried in a waist belt. The suit also has a wrap for each calf, four vertical straps (two per leg), sensors, and cables. The cables are attached to the material near each ankle joint; motors pull on the cables to help support the wearer's movement. Some of this force is also transmitted through the vertical straps to the front of the waist belt to help with hip gait motion.

When the wearer lifts a foot to take a step, he pulls on the cables, which helps lift the wearer's leg. Then, as the foot swings forward, another cable, attached to the toe cap of the shoe, tightens to help raise the toe so that it does not drag on the ground.

The sensors monitor the person's movement. That information is analyzed by a microprocessor, worn on the belt, which determines when to send power to the motors. This enables the suit to deliver assistance exactly when help is needed to take a step, lift a foot, push off the ground, or place the foot down. The soft exosuit also adjusts to match a healthy person's gait.

Are you working with anyone to manufacture your exosuit?

Last year, we partnered with ReWalk Robotics of Marlborough, Mass., and we're collaborating to bring the technology to those who can benefit from it.

What led you to found the Harvard Biodesign Lab, and what other projects are in the works?

The lab develops fundamentally disruptive approaches around technologies related to wearable soft robotics. This requires a multidisciplinary team that includes researchers in robotics, apparel design, human biomechanics, and physical therapy. We perform medical and market research in different application areas to understand the problems and opportunities, and identify advances needed to address unmet needs.

Current projects include inflatable soft robotics for upper-extremity applications, and braces to help prevent injury and promote recovery. We are also developing educational materials to train future innovators in engineering design and soft robotics.

What about the Harvard Medical Device Innovation Initiative and Soft Robotics Toolkit you helped establish?

The medical initiative spun out of the Harvard Biodesign Lab. Launched in 2011, the initiative develops educational programs that train the next generation of innovators, giving them hands-on experience in developing cutting-edge medical devices and instruments for real-world problems. The initiative includes lectures, courses, and a summer program.

We are also developing educational materials to be used at soft robotics workshops and competitions in high schools. The Soft Robotics Toolkit, spun out of the Harvard Biodesign Lab, supports the design, fabrication, modeling, characterization, and control of soft robotic devices. We hope the toolkit will advance the field of soft robotics by allowing designers and researchers to build upon each other's work. It includes an open-source fluid-ics control board, design documentation describing a wide variety of soft robotic components including actuators and sensors, and downloadable files used to design, manufacture, and operate soft robots. ◆

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