the institute

DIVING INTO DIGITAL SENSES
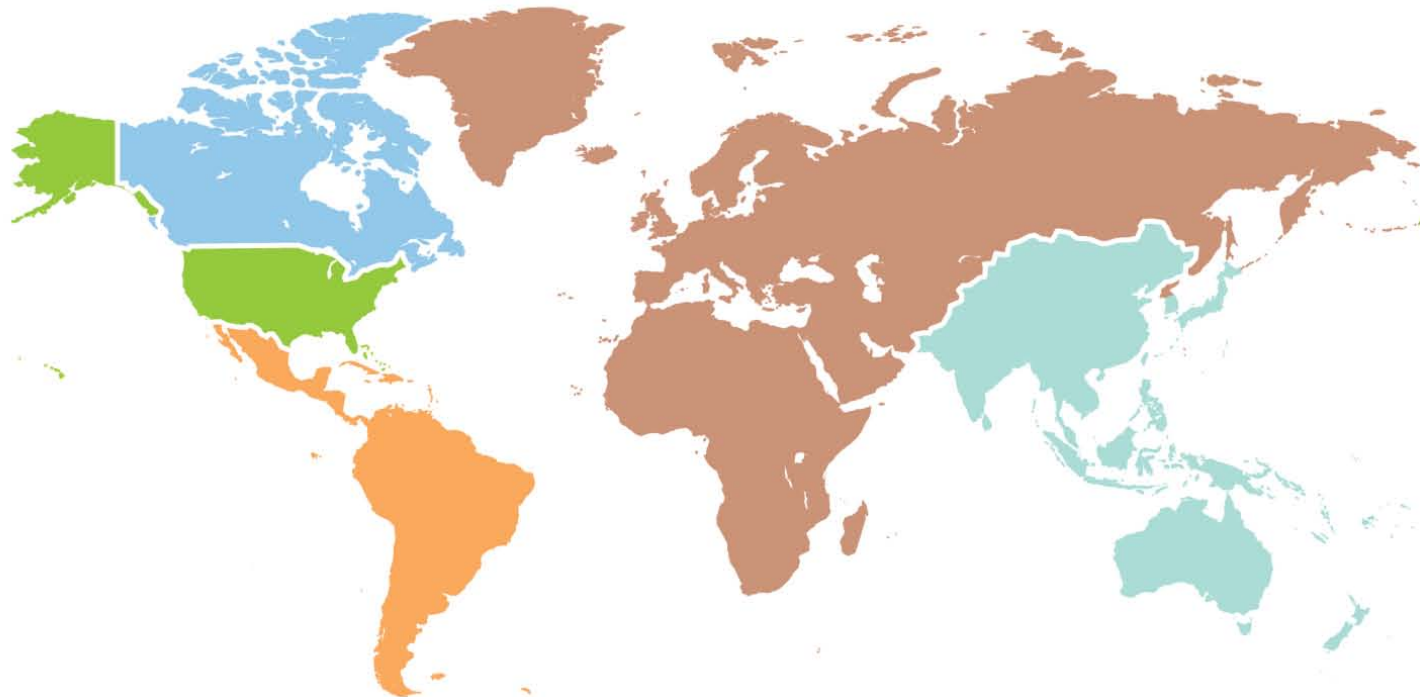
IEEE

REGION NEWS

REGION 1 — NORTHEASTERN UNITED STATES

■ **Mohawk Valley (New York) Section** forms IEEE Systems Council chapter.

REGION 2 — EASTERN UNITED STATES

■ Student branch at the **University of Maryland, College Park,** forms IEEE Industry Applications Society chapter.

REGION 3 — SOUTHEASTERN UNITED STATES

■ Student branch formed at **Kennesaw State University, Georgia.**

■ **Richmond (Va.) Section** forms IEEE Computer Society chapter.

REGION 5 — SOUTHWESTERN UNITED STATES

■ **St. Louis Section** forms IEEE Young Professionals (YP) affinity group.

■ **Central Texas Section** forms IEEE Sensors Council chapter.

REGION 6 — WESTERN UNITED STATES

■ **Buenaventura (Calif.) Section** forms IEEE Photonics Society chapter.

■ Student branch at the **University of California, Berkeley,** forms joint chapter of the IEEE Industry Applications and IEEE Power Electronics societies.

REGION 7 — CANADA

■ **Montreal Section** forms IEEE Power Electronics Society chapter.

■ Student branch at **Concordia University, Montreal,** forms IEEE Industry Applications Society chapter.

REGION 8 — EUROPE, MIDDLE EAST, AND AFRICA

■ Student branches formed in **Bahrain** at **Ahlia University, Manama,** and **AMA International University, Salmabad.**

■ Student branch at **Helwan University, Egypt,** forms IEEE Power & Energy Society chapter.

■ Student branch formed at **Sheffield University, England.**

■ Student branches formed in **Accra, Ghana,** at **BlueCrest College** and **Ghana Technology University College.**

■ Student branch formed at the **University of Brescia, Italy.**

■ Student branch formed at **Kaunus University of Technology, Lithuania.**

■ **Republic of Macedonia Section** forms IEEE YP affinity group.

■ Student branch at **University of Coimbra, Portugal,** forms IEEE Engineering in Medicine and Biology Society chapter.

■ Chapter of IEEE–Eta Kappa Nu (IEEE's honor society) formed at the **University of KwaZulu-Natal, Durban, South Africa.**

■ Student branch at the **National Engineering School of Monastir, Tunisia,** forms IEEE Robotics and Automation Society chapter.

REGION 9 — LATIN AMERICA

■ Student branch at **Universidad del Salvador, Buenos Aires,** forms IEEE Power & Energy Society chapter and IEEE Women in Engineering (WIE) affinity group.

■ Student branch at **Universidade de Brasília, Brazil,** forms IEEE Computer Society chapter.

■ **Chile Section** forms IEEE Geoscience and Remote Sensing Society chapter.

■ Student branch at **Universidad del Norte, Barranquilla, Colombia,** forms chapters of the IEEE Circuits and Systems and IEEE Robotics and Automation societies.

■ Student branch at **Universidad San Francisco de Quito, Ecuador,** forms IEEE Electron Devices Society chapter.

■ Student branch at **Universidad Centroamericana José Simeón Cañas, San Salvador,** forms IEEE Communications Society chapter.

■ Student branch at **Instituto Tecnológico de Ciudad Guzmán, Mexico,** forms IEEE Computer Society chapter and IEEE WIE affinity group.

■ Student branch at **Universidad Autónoma de Guadalajara, Zapopan, Mexico,** forms chapters of the IEEE Technology and Engineering Management and IEEE Vehicular Technology societies.

■ Student branch formed at **Universidad Andina Néstor Cáceres Velásquez, Juliaca, Peru.**

■ Student branch at **Universidad Nacional del Altiplano, Puno, Peru,** forms IEEE Industry Applications Society chapter.

REGION 10 — ASIA AND PACIFIC

■ Student branch at **Macquarie University, Sydney,** forms IEEE WIE affinity group.

■ Student branches in **Bangladesh** at **Ahsanullah University of Science and Technology, Jahangirnagar University, North South University,** and the **University of Dhaka** form WIE affinity groups.

■ **Macau (China) Section** forms IEEE Council on RFID chapter.

■ Student branches in **India** at **Lal Bahadur Shastri Institute of Technology for Women, Jeppiaar Institute of Technology,** and **Netaji Subhash Engineering College** form IEEE Robotics and Automation Society chapters.

■ **Indonesia Section** forms chapters of IEEE Computer, IEEE Education, and IEEE Power Electronics societies.

■ Student branch formed at **Syiah Kuala University, Banda Aceh, Indonesia.**

■ Student branch formed at **University of Fukui, Japan.**

■ **Kwangju (Korea) Section** forms IEEE YP affinity group.

■ Student branch formed at **Universiti Teknikal Malaysia Melaka, Durian Tunggal.**

■ Student branch formed at **Abasyn University, Peshawar, Pakistan.**

■ **Taegu (South Korea) Section** forms IEEE YP affinity group.

■ Student branch formed at **Hongik University, Seoul, South Korea.**

■ Student branch at **Tra Vinh University, Vietnam,** forms IEEE Microwave Theory and Techniques Society chapter.

COVER AND THIS PAGE: ISTOCKPHOTO

BRIEFINGS

Galuchie

Herz Award Goes to Galuchie

KAREN GALUCHIE has been chosen to receive the 2016 IEEE Eric Herz Outstanding Staff Member Award "for exceptional staff leadership and for support and service to IEEE volunteers in achieving the philanthropic objectives of the IEEE and the IEEE Foundation." She was presented with the award last month at the IEEE Meeting Series in New Brunswick, N.J.

Galuchie is executive director of the IEEE Foundation, the organization's philanthropic arm, in Piscataway, N.J. During her 19 years with the Foundation, she has helped raise millions of dollars to support IEEE educational, humanitarian, historical preservation, and peer recognition programs including the IEEE Power & Energy Society Scholarship Plus Initiative, EPICS in IEEE, IEEE Smart Village, and IEEE REACH Through History.

She has donated her US $5,000 cash prize to the IEEE Foundation Fund. With the donation, she says, she hopes to encourage others to make a gift to the Foundation, helping to bring the promise of technology—and the knowledge to use it—to individuals and communities all over the world.

The IEEE Board of Directors created the Herz Award in 2005 to honor longtime volunteer Eric Herz, who served in many capacities including IEEE general manager and executive director. The award recognizes a present or past full-time IEEE staff member with at least 10 years of service for demonstrated contributions over a long period of time.

The nomination deadline for the 2017 IEEE Herz Award is 15 January. For more information, visit http://www.ieee.org/about/awards/recognitions/recognitions_herz.html.
—*Amanda Davis*

Annual Election Results Are In

IEEE LIFE SENIOR MEMBER Jim Jefferies has been chosen as 2017 IEEE president-elect. He will begin serving as IEEE president on 1 January 2018. Meanwhile, the proposed amendment to the IEEE Constitution did not receive the number of votes it needed to pass.

Jefferies garnered 23,865 votes in the election. The runner-up, IEEE Fellow Wanda Reder, received 23,327 votes. The results were made official when the IEEE Tellers Committee report was accepted by the IEEE Board of Directors in November.

Jefferies is a retired AT&T and Lucent Technologies executive who in 33 years rose from manufacturing engineer to vice president. He was responsible for teams that transferred glass technology from Bell Telephone Laboratories and developed fiber-optic cables at AT&T. He also served as logistics vice president, responsible for international distribution, quality assurance, and export planning.

After retiring in 2000, he teamed with fellow Stanford graduates and served as chief operating officer at USBuild, a company that developed supply-chain solutions for homebuilders.
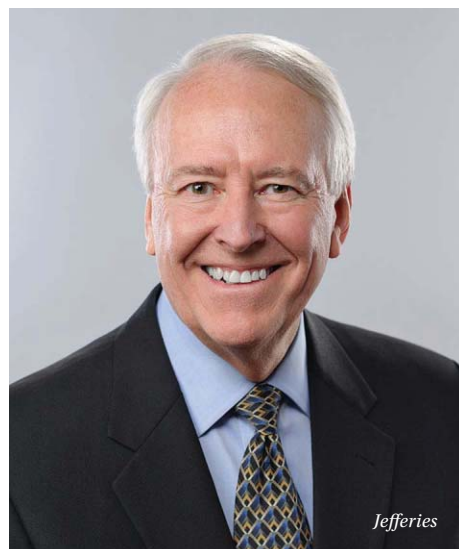
He has been an IEEE volunteer for years. As 2015 IEEE-USA president, he helped the organization expand its focus on young professionals, public policy, and visibility.

On the IEEE-USA board of directors from 2009 to this year, Jefferies served as vice president of government relations and of professional activities. He has provided valuable expertise to the IEEE Audit and Employee Benefits committees, and is currently chair of the IEEE-USA Entrepreneurship and Innovation Policy Committee. He served as 2012–2013 director of Region 5 and was 2008 chair of the IEEE Denver Section.

He is a registered professional engineer and a member of IEEE–Eta Kappa Nu, the organization's honor society.

To find out who was chosen IEEE-USA president-elect, IEEE Technical Activities vice president–elect, and more, read the annual election results at http://www.ieee.org/about/corporate/election/election_results.html.
—*A.D.*

Jefferies

ONLINE

at theinstitute.ieee.org

TECH HISTORY The Dolby A noise reduction system for studio magnetic film recordings debuted 65 years ago. The first film to use the technology for its entire production was *A Clockwork Orange*, which premiered in December 1971.

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

Calendar *of Events*

DECEMBER

1–3
IEEE Women in Engineering (WIE) Forum USA East, Boston

10–11
IEEE 5G Summit, Kuwait

12–14
IEEE International Conference on Smart City, Sydney

12–14
IEEE World Forum on Internet of Things, Reston, Va.

19–21
IEEE International WIE Conference on Electrical and Computer Engineering, Pune, India

JANUARY

2–4
IEEE Rising Stars Conference, Las Vegas

8–10
IEEE International Conference on Consumer Electronics, Las Vegas

28
IEEE Region 4 virtual meeting

FEBRUARY

5–9
IEEE International Solid-State Circuits Conference, San Francisco

8–13
IEEE Meeting Series, New Orleans

CLOCKWISE FROM TOP: IEEE; ISTOCKPHOTO (3); DAVID SUTPHIN STUDIO

SPECIAL REPORT

DIGITAL SENSES

TECHNOLOGY THAT LETS PEOPLE enhance reality or even escape it is quickly evolving. We can now experience augmented reality (AR) with smartphone apps that overlay on the scene in front of the user fun imagery such as animated Pokémon characters. And there are smartglasses and devices, like the Microsoft HoloLens, a headset that projects images and information. Virtual reality (VR) headsets such as Oculus Rift and the HTC Vive let people fully immerse themselves in video games, movies, and training scenarios. Prosthetics, brain-machine interfaces, and other human augmentation technologies can restore sensory experiences lost by people with disabilities and enhance the senses of the able-bodied.

Leading the way in AR, VR, and human augmentation technologies, which are the focus of this special report, is the IEEE Digital Senses Initiative [article, right]. The group is working with academia and industry to organize events, foster collaborations, create standards, and remove barriers to development and widespread adoption.

AR is already starting to change the way we work. Headsets can now superimpose repair instructions over machinery and project holograms of 3-D models of construction sites [p. 6].

VR applications are becoming so realistic that some worry that people might eventually prefer a virtual world to the real world. But others say it's more likely that VR will help people better understand the world around them, and even themselves, in ways not possible before. Soon, VR headsets might be used to immerse users in news stories, for example, or to prepare them for a natural disaster [p. 8].

We feature IEEE Member Ori Inbar, cofounder of a venture capital firm that plans to provide US $10 million in funding to AR-related startups [p. 16]. And we profile IEEE Senior Member Yu Yuan, chair of the IEEE Digital Senses Initiative [p. 17].

Included in this issue are tips to help you ask for a raise or increase your benefits at work by articulating your value to the company [p. 10].

In his final column for *The Institute*, IEEE President Barry Shoop reminds readers to learn from the past and points out that the organization needs to engage more members from industry [p. 13]. And speaking of the president, turn to page 3 to learn whom voters chose to be the 2017 IEEE president-elect.

Visit theinstitute.ieee.org for blog posts related to this special report. To comment on what you've read in this issue, email the editors: institute@ieee.org.

—*Amanda Davis, senior editorial assistant*

Blurring the Lines Between Virtual and Real Worlds

An IEEE initiative seeks to advance augmented reality, virtual reality, and human augmentation technologies BY KATHY PRETZ

WITH THE popularity of augmented reality games, virtual reality headsets, and bionic body parts, interest has never been greater in technologies that blur the lines between the digital and physical worlds.

AR brings computer-generated graphics to life, superimposing near lifelike, digitally processed images on what the person actually sees in the real world. VR immerses people inside virtual worlds that mimic the real one or fictitious ones. Body implants, prosthetics, brain-machine interfaces, and other human augmentation technologies, combined with VR applications, can restore sensory experiences lost by some people with disabilities. And the senses of able-bodied people can be enhanced.

All three emerging fields face common challenges. These include the lack of collaboration among companies developing the technologies; gaps in technical standards, if those standards even exist; and a lack of content, to say nothing of killer apps.

Taking on those and other issues is the job of the year-old IEEE Digital Senses Initiative (http://digitalsenses.ieee.org). The DSI was launched last year by the IEEE Future Directions Committee, the organization's R&D arm.

"Our goal is to facilitate disruptive innovations that make it difficult or nearly impossible to distinguish between virtual worlds and real worlds," says IEEE Senior Member Yu Yuan, the initiative's chair. Yuan is CEO of Senses Global Corp., a tech startup in Shenzhen, China, focused on developing new technologies around VR, AR, and human augmentation.

The initiative bundled together the three fields because they all involve technologies that "hack" human senses, Yuan says.

"The DSI is dedicated to advancing technologies that capture and reproduce the real world or synthesize the virtual world, and add the stimuli of human senses," he says. "Our scope includes combining reproduced or synthesized stimuli with natural stimuli and helping humans or machines to perceive and respond to them."

AR, VR, and human augmentation technologies are all growing fields, he notes, but the lack of collaboration among participating entities has become a barrier to development and widespread adoption.

"IEEE is perfectly positioned to unite industry and academia to achieve such collaboration," Yuan says.

NEW AND IMPROVED

All three technologies have been around for decades, but early applications were lacking, according to Yuan, because their virtual stimuli did not feel real enough and the overall experience was not rich enough.

"That's why market growth in these fields actually stopped back in the 1990s," he says. But the technologies have been improved to the point where "people now feel some of the devices are enjoyable enough to wear and use," he continues.

ISTOCKPHOTO

ISTOCKPHOTO

The 3-D Body Processing Group is devising standards for the capture, processing, and use of 3-D data on various devices so they can communicate with one another and transfer information. The group also plans to tackle security, privacy, metrics, communications and sharing protocols, and methods for assessing results.

The DSI is also working with the Industry Connections program to form a Digital Senses Alliance, which would foster cross-industry and cross-disciplinary collaborations to identify gaps in technologies and standards.

The lack of compelling and far-reaching content for AR and VR is another pain point for industry, according to Yuan. "Everyone says that content is king, and we all need it," he says, "but developing it has been a struggle."

Training content developers is key. To that end, the initiative has partnered with VR First and the Uniquedu Education Group. VR First provides state-of-the-art facilities around the world for VR creators. The DSI and VR First are working to build learning labs in engineering universities and centers of excellence in industrial parks. Uniquedu, headquartered in Beijing, is creating massive open online courses on developing AR and VR content—which IEEE plans to offer.

Other educational activities under way include webinars, IEEE Distinguished Lecturers series, VR video competitions for students, and hackathons where participants can produce working prototypes.

Several publications are in the works as well. One is a yearly report covering upcoming advances. Another will highlight best practices for filmmakers and game developers [see p. 14].

To get the word out about its efforts, the initiative is developing a promotional video using VR technology. And it has begun two mobile app projects focused on expanding the reach of IEEE events. The Conference AR app will use the technology to help attendees at IEEE conferences find meeting rooms and exhibit booths, and superimpose over the attendees' facial images their names, employers, and technical interests, Yuan says. The Meeting in VR app will help attendees of teleconferences and meetings held via Skype, Google Hangout, or WebEx to collaborate virtually.

"The next generation of the technologies should create virtual worlds that are so real that a person won't be able to tell the difference," Yuan says. "This will be the ultimate experience that AR and VR could provide." ◆

"And now they're patient enough to wait for further improvements."

AR games and VR headsets made inroads this year. Pokémon Go, the location-based, augmented-reality game, was all the rage, with more than 500 million downloads as of September. Market analyst CCS Insight estimates that the total VR device market will be worth US $1.5 billion this year and climb to $11 billion by 2020.

Because AR allows for a mix of real and virtual objects, Yuan predicts we'll see new types of services and business models in retail, transportation, manufacturing, construction, and other industries [see p. 6].

"AR will change how we interact with the environment and the services around us," he says.

VR applications will most likely be widely used first in live broadcasts of sporting events.

The technology also could prove beneficial to people with disabilities. "Those who can't run or jump in the real world will be able to do so in the virtual world," Yuan says. "They'll also be able to travel virtually to places they could never visit in person."

And VR could be used to restore and enhance a person's senses. For example, realistic haptic interfaces could let people "touch" virtual objects that feel similar to the real things.

ACTIVITIES UNDER WAY

The DSI has been busy during the past year on a number of fronts.

The initiative has been sponsoring several IEEE Standards Association Industry Connections groups to propose technical standards in the three areas [see p. 15].

The Augmented Reality in the Oil/Gas/Electric Industry Group is exploring how head-mounted displays, head-up displays, and other applications might benefit the three fields. The Smart Glasses Roadmap Group is working to overcome hurdles blocking the adoption of smartglasses in a number of markets and applications.

How Augmented Reality Is Changing the Way We Work

AR devices can assist in a number of ways BY **AMANDA DAVIS**

NDUSTRY IS A test bed for AR's capabilities. Workers on construction sites, in water treatment plants, and elsewhere are trying smart helmets and headsets that can display step-by-step instructions to help them fix faulty machinery. And they can communicate and share what they're looking at with colleagues, and ask their advice, even if they're thousands of kilometers apart.

These are just some of the benefits of wearables like the DAQRI Smart Helmet (DSH) [photo, center] and the Microsoft HoloLens headset [bottom].
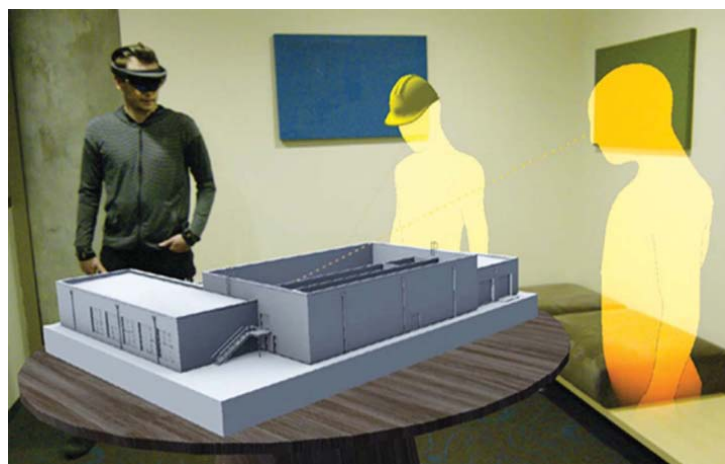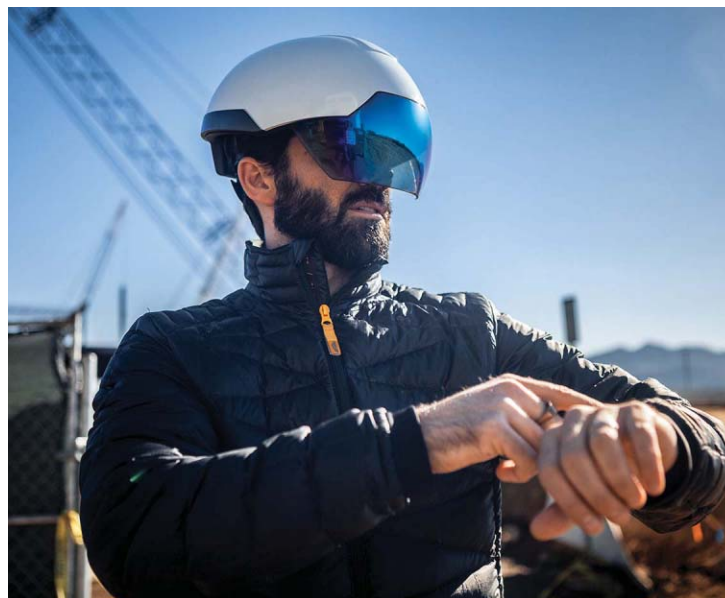
HANDS-FREE

It can be awkward to repair or recalibrate a piece of complicated machinery while holding onto an operator's manual to read instructions. AR helmets from DAQRI will overlay the instructions on the machinery, freeing up the worker's hands. "This reduces the time it takes to complete a task and cuts down on errors," says Paul Sweeney, vice president of sales and general manager for the Los Angeles company.

DAQRI's 4D Studio software uploads 3-D models of machinery and interactive instructions for its repair to the DSH. Customers can add training videos, along with images and text from other manuals.

Safety lenses in the helmet double as a screen for the graphics. The Smart Helmet also has an embedded camera and transceiver so the wearer can contact and chat with a colleague in another location. This Remote Expert feature lets the wearer connect with a colleague via voice over Internet Protocol and share what he's seeing through the other person's computer.

Instead of GPS, the device uses Intellitrack technology, a location-based service that combines visual information from the front-facing camera, a 3-D map of the job site, and an internal sensor that detects a person's movement to keep track of where the helmet is in relation to its surroundings.

Also, thermal cameras in the DSH can visualize for the wearer the temperature of the surrounding area. That view can help predict equipment failures before they happen because, notes Sweeney, many machines "run hot" before they break.

Several companies, including Emerson Electric, a software and service provider in St. Louis, and Parker Hannifin, an engineering firm in Mayfield Heights, Ohio, are beta-testing the helmet, which costs US $15,000.

VIRTUAL COLLABORATION

Microsoft HoloLens headsets can make their wearers feel like they're in two places at once. It allows them to see their surroundings while 3-D holographic images of walls, machinery, and equipment are projected in front of what they're viewing.

I tried out the $3,000 headset at this year's Augmented World Expo, courtesy of Scott Aldridge, leader of the innovation group at CDM Smith, an engineering and construction company based in Boston. The group is exploring possible applications for AR and VR devices for its customers.

The DAQRI Smart Helmet [top] projects instructions on machinery to let people work hands-free. The Microsoft HoloLens [bottom] projects images in front of the wearer and allows workers to collaborate with each other in the form of avatars.

The headset lets people seemingly walk around and through a 3-D model of, say, a construction site or manufacturing plant, or even a virtual blueprint of a proposed building. I walked through a model of a water treatment plant projected by the headset. Even though I was walking around the Expo's press room, I felt like I was inside the facility.

HoloLens wearers can use gesture control (a wave or a pinch of their thumb and forefinger in front of the headset) to get a bird's-eye view of the building or zoom in and "step inside" a room and see its walls and machinery.

They also can bring up and apply a virtual measuring tape. Just look at the corner of one wall, trace a line to the next corner, and say the words "create measurement," and the tool measures the distance between those two points. The virtual measuring tool is especially useful for customers planning to install equipment in a new building: They can create a hologram to scale of a large piece of equipment destined for the building, and make sure it fits where they want it to before they pay for a crane to haul it in.
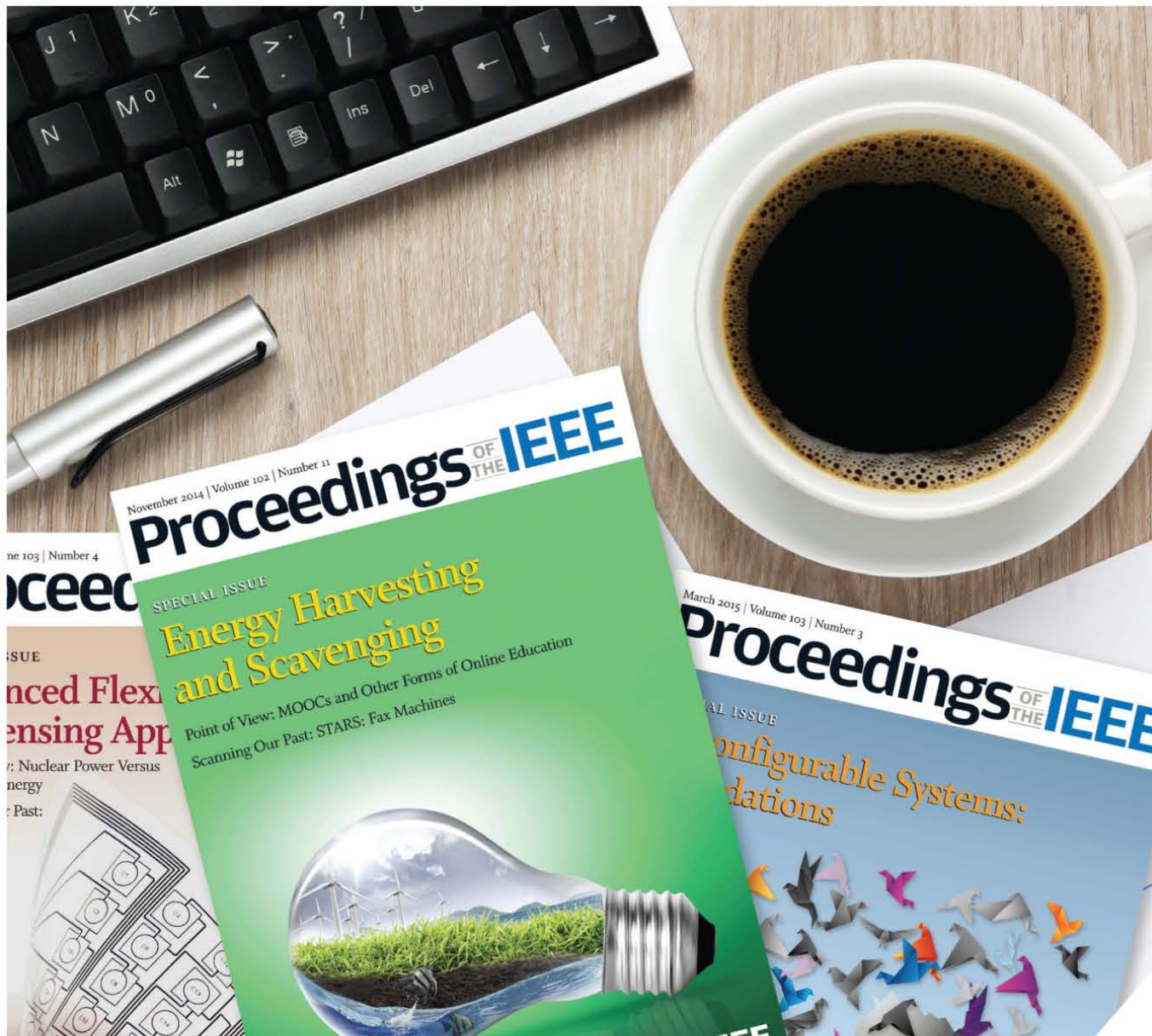
If two or more people are wearing the headsets uploaded with the same 3-D model, they can communicate with one another through embedded microphones and see each other as holographic avatars, even if they're in different locations.

"We've had as many as 12 participants in a dozen different locations working together inside a model using our HoloLens communication and collaboration application," Aldridge says. "Even if you don't have HoloLens you can participate from a laptop and be represented in the environment in avatar form."

In my demo, Aldridge's avatar was a faceless yellow figure wearing a hard hat. I could even see what he was looking at in the virtual room, because a dotted line went from his avatar's face to a piece of equipment. This feature can make colleagues thousands of kilometers apart feel as though they're in the same space, figuring out together the best location for, say, water pipes.

In addition to the HoloLens, Aldridge's group is exploring similar industry applications for other devices, such as the Oculus Rift and HTC Vive virtual-reality headsets. They also plan to try the Playstation VR headset and Meta One AR smartglasses once those are available.

"We believe that mixed reality experiences will empower the next generation of collaboration in industry, going far beyond what today's video conferencing and screen sharing programs can provide," he says. ◆

CENTER: DAQRI; BOTTOM: OBJECT THEORY

Moving Closer to Reality

VR can help people feel empathy and prepare them for natural disasters   BY **MONICA ROZENFELD**

THE ANIMATED FILM *WALL·E* paints a dystopian future in which people are glued to their individual video screens, oblivious to their surroundings. In the real world, similar concerns are being raised about virtual reality. People who wear VR headsets can immerse themselves in virtual worlds and be conscious of little else.

VR headsets provide 360-degree views of digitally processed scenes filled with sights and sounds. Someone wearing a headset and standing on a virtual island might, for example, move her head to the right to see palm trees and to the left to see the ocean waves. A sense of embodiment is created—people wearing a headset feel part of the scene, as if they were physically there.

Some observers say they worry people might eventually prefer the virtual over the real world. But others say it's more likely that VR will instead help people better understand the world around them, and even themselves, in ways that were not possible before.

Here are several examples of how VR could bring people closer to reality.

Virtual reality headsets, like the one in the photo at top left, are being used to immerse people into news stories. Users can experience standing on line at a food pantry [left] as a man collapses from a diabetic coma. In the scene above, wearers witness the plight of children displaced in Syria's civil war.

EEMBLEMATIC GROUP (3)

EYEWITNESS NEWS

Watching news reports about poverty or crime can leave some viewers desensitized to the suffering in the world. VR could help people become more empathetic. When journalist Nonny de la Peña was filming reports about hunger and war, she wanted to find a way for viewers to connect with the people in her stories, so she used VR. De la Peña is the CEO of Emblematic Group, a company in Santa Monica, Calif., that develops content for VR systems.

De la Peña turned a news story about people lined up at a food bank into a VR experience to see how viewers would react to it. When people she had chosen put on VR headsets, they found themselves in a line with others waiting outside a food pantry. Suddenly, a man in the virtual line collapsed, his body shaking from a diabetic coma triggered by hunger [see photo, bottom left]. Those in de la Peña's group found themselves walking toward the man, as if they could help him. Some reported later that they had a feeling of helplessness because they couldn't do anything for the fallen man. A few shed tears. And this occurred even though they knew they were really in an empty room.

For Project Syria, de la Peña wanted to show viewers what it was like for Syrian children living through that country's civil war. She obtained news footage of children on the streets in Syria as bombs went off. Her VR wearers watched a girl of about 9 singing a song. After about 20 seconds a bomb exploded on the scene. The girl disappeared from the screen; others on the street ran to get away from the blast. Those wearing the headsets reported they felt alarmed and shaken.

Some said afterward they would donate to food banks and Syrian refugee programs.

"With VR," de la Peña says, "it turns out you can feel like you're in two places at once: in the virtual space as well as the space you're actually in—known as a duality in presence."

In a TED talk on the future of news reporting, she used those two examples of VR experiences to show how people can be prompted to tap into their empathy.

"It wasn't until I started working with virtual reality that I started to see really intense reactions from people to news stories," she says.

THE VERDICT IS IN

During many criminal trials, lawyers show jurors photographs and drawings in an attempt to explain what happened at a crime scene. But it can be difficult for jurors to comprehend details, like the trajectory of a bullet, by just looking at images. That's why a team at the University of Zurich is experimenting with VR headsets to immerse jurors in the scene and give them a better idea of what happened so they can deliver better-informed verdicts.

AN ESCAPE PLAN

After the 2011 Tohoku earthquake and tsunami in Japan, researchers from the Aichi University of Technology, in Gamagori, Japan, designed a VR program that simulates a tsunami moving through a city [see photo, top right]. By wearing a headset, people can experience an enormous wave rushing through the streets. The goal is to help citizens prepare so they can remain calm and think clearly during an actual tsunami.

In one tsunami simulation, the person wearing the VR headset is a driver whose car is in danger of being washed away by the rushing water. The scenario, designed to make headset wearers feel helpless, should teach them not to try to escape a tsunami in a car but abandon the vehicle and run to higher ground. To help make the scene realistic, the designers analyzed video footage taken from car-mounted cameras retrieved from the 2011 tsunami and interviewed survivors about their experiences.

VIRTUAL THERAPY

VR also might help people who suffer from anxiety, depression, and post-traumatic stress disorder. For those fearful of speaking in public, for example, the mobile app Public Speaking Simulator offers the experience of speaking in front of a virtual room packed with a large crowd [see photo, bottom right]. The size and behavior of the crowd can be adjusted. Would-be speakers can accustom themselves to the sounds a crowd makes, including potential distractions such as coughing and whispering. The app sounds an alert if the speaker spends too much time talking to one side of a room at the expense of the other, for example, or says "um" too often.

VR is also being used to treat soldiers with PTSD. The headsets bring them back to the sights and sounds of a war zone. The more the veterans are exposed to the virtual stimuli of gunfire and explosions, the thinking goes, the better they can be trained not to confuse them with the everyday sounds of, say, city traffic and firecrackers.

Researchers from the Aichi University of Technology, in Gamagori, Japan, developed a VR program [top] to help prepare people for a tsunami. VR could also be used to relieve people of their anxieties. The mobile app Public Speaking Simulator [above] simulates a crowded room with ambient noise so users can practice speaking in front of a live audience.

The technology also is being considered for helping assault victims relive their experiences. Gradually the original debilitating memory will exert less power on their psyche. The same idea is being tried for victims of traumatic car accidents.

Researchers at University College London found that role-playing using VR can help people with depression by alleviating their negative thoughts and helping them be more compassionate to themselves. Patients observe a talk therapy session designed for the VR experience. Through the headset, the patient sees the session from the therapist's perspective, and then from the patient's. As the therapist, the wearer usually becomes concerned about the patient's well-being.

Nine of the 15 patients who participated in the study reported reduced symptoms of depression after three sessions—serving as a proof of concept for researchers to continue work in this area. ◆

Get the Most From Your Next Salary Negotiation

Tips on initiating a conversation with your manager and articulating your value BY **ANTHONY GOLD**

HERE'S A PAINFUL yet common occurrence: You discover that a coworker who doesn't seem to work as hard as you do (or as well) earns a higher salary—perhaps a lot higher. Or maybe you feel stuck: You think you've brought a lot of value to the company, but your manager isn't offering a raise or promotion. What should you do?

GET OFF ON THE RIGHT FOOT

First, here's what you shouldn't do: Tell your boss about the pay disparity or blurt out that you're not making enough and want a raise. That not only creates an awkward situation but also puts your manager in the defensive position of justifying one person's salary over another's. There very well might be legitimate reasons for the difference. For example, if you're comparing your earnings to someone else in a similar position, that person might have negotiated a higher starting salary. You, on the other hand, might have accepted what was offered when you joined the company.

Instead, first validate from outside sources that your salary is indeed below where it should be. Glassdoor,

Salary.com, and other websites can make it easy to gather that information. Then, ask for a meeting with your manager.

At the meeting, start by articulating the value you bring to the company. You should discuss your accomplishments and the effect they have had. That might be time saved, revenue increased, costs cut, the impact you've had on the company's brand—things that truly matter to the business.

Follow that up with positive comments about why you like working for the company and, in particular, for your manager. And then say something like this: "One thing is troubling me. I feel that, given my role and the impact my work is having, I'm undercompensated. And I'd really like your help so that we can address this."

THE POWER OF SILENCE

A successful salary renegotiation always starts with your knowing at least two points: You're being paid less than your market value, and your accomplishments are having a positive effect on the company. If this holds true, you'll find your salary renegotiation is simpler than otherwise.

A great way to get a raise or promotion is first to elaborate clearly the difference you're making, as well as your desire to contribute even more to the organization. Then ask for the amount you want, but phrased in a way that makes it clear the increase will enable you not only to be more motivated but also to have an even greater impact.

Your manager will either agree to look into your request, or she'll say she can't offer you a raise at that time.

No matter how your manager responds, say nothing. That can be hard because silence feels awkward. But silence can be useful: The silence is begging to be filled, and your manager will fill it. She may come back with a willingness to explore your situation further, perhaps meet you halfway, or with a justification for why the company cannot increase your salary—all of which can be helpful.

If it's a justification for why the company can't pay you more (for example, the salary budget is fixed and no money is left) then that information can lead to the two of you brainstorming other ways to address the issue—with a performance bonus, say, or extra vacation time. The conversation also might lead to

a discussion about whether you are on the right path to a promotion and what you must do to get there.

Following that, here are questions you can ask to help move the discussion forward:

- What is the salary range for someone in my position, and is that range fixed?
- Have exceptions been made, and if so, what qualities did that person have?
- What skills and level of responsibility are required for the next pay grade?
- If a salary increase is not an option at this time, can we negotiate other benefits, such as vacation time?

These questions can promote a discussion that not only will help you better understand what's going on in your company but also help you develop a better rapport with your manager.

A TWO-WAY STREET

Here's another question—perhaps the most powerful one—that can truly help create a collaborative environment for moving the discussion forward: "How can we close the gap?" The gap refers to the space between what you feel is fair and what the company is offering.

Note the focus is on *we*. This is the core of collaborative negotiation. Within this framework, there are no winners or losers—just you and your manager figuring out ways to create a win-win situation.

Remember, the company wants and needs you. It wouldn't have hired you, or continued to employ you, if that weren't the case. A collaborative negotiation is a way to find a solution that keeps you motivated while remaining within the company's budget.
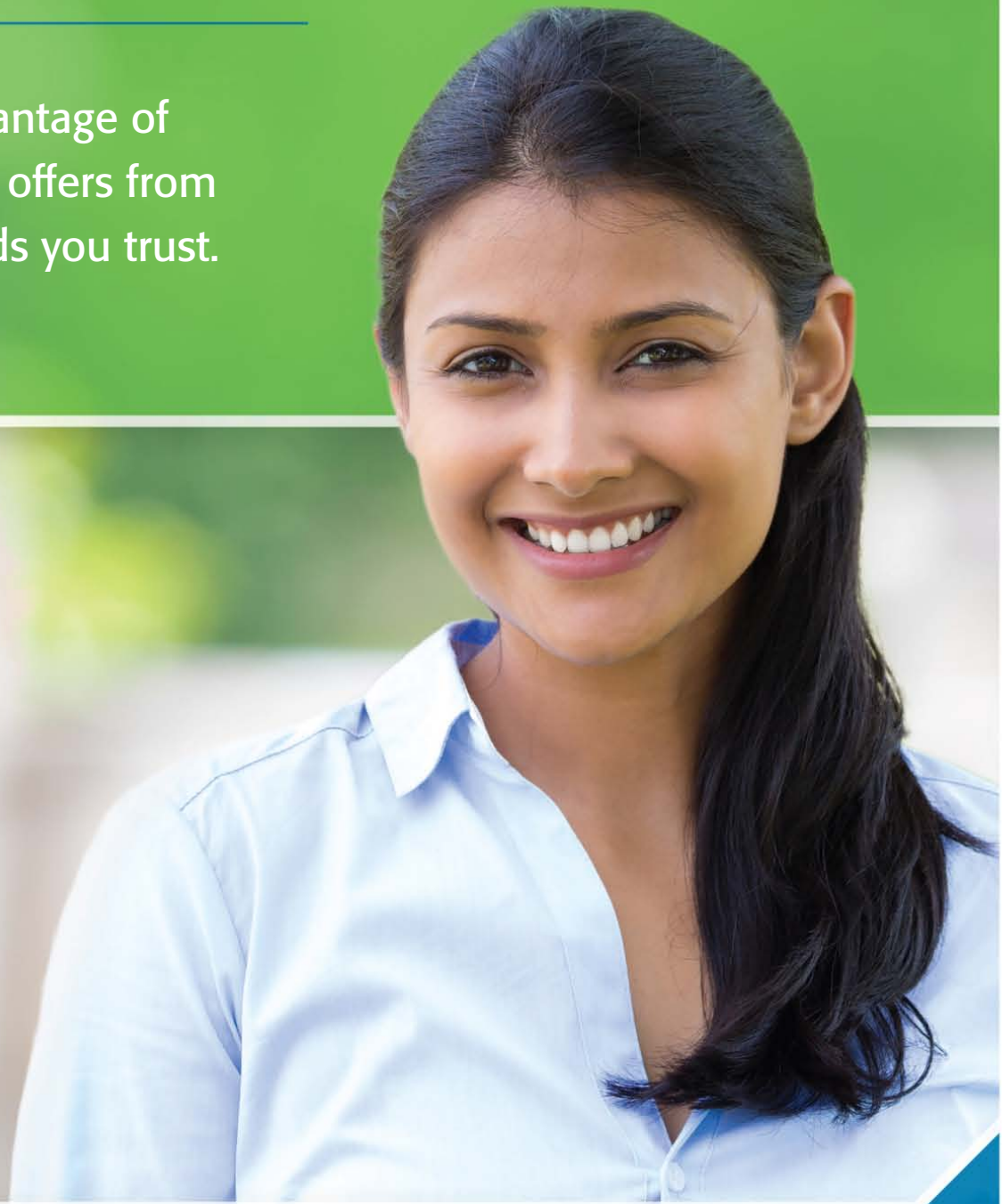
And remember that salary is just one piece of the puzzle. You also can consider perks such as extra time off, flexible hours, or incentive pay (for achieving certain milestones in a given time).

If the company won't budge on any of your requests, and you still want to work there, ask for a review in six months to assess your contributions. Be sure to ask what you would need to accomplish in those six months to warrant an increase. ◆

Anthony Gold is a career coach, entrepreneur, investor, and philosopher who recently cofounded ROAR for Good, a social-impact company in Philadelphia developing smart jewelry to reduce assaults and empower women. He is also a regular blogger for The Institute.

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OPINIONS

Sparking Conversation

In September, The Institute *focused on the state of engineering education and the need for qualified engineers, and in August it looked at the future of banking. We also blogged about the positive effect that AR games like Pokémon Go can have on humanity—as well as their drawbacks. The conversation continued on our website.*

ENGINEERING EDUCATION

In a world characterized by rapidly accelerating technologies, it is essential that engineers continue their professional development. When I studied engineering in school, professors would teach from old and often outdated materials, and all students cared about was what was going to be on the exams. After I earned my bachelor's degree, I found a way to better my career through workshops and seminars. Later I participated in mentoring programs, attended networking events, and enrolled in online classes. After 30 years in the engineering profession, I continue to pursue education, and I do not plan to stop.

—Qusi Alqarqaz

There seems to be an influx of people studying engineering who are interested in being gainfully employed rather than having a keen interest in the discipline itself. But once they enter the field, they are often disappointed by their earnings.

—alphasierra

Don't go into engineering (or anything) for the money; go into it for the personal satisfaction. Otherwise, you will be sorely disappointed. Personal satisfaction is priceless.

—pjgeneva

There are several negative factors that turn off young people from careers in engineering and science. Some industries do not always provide career-long jobs. Declining salaries are also a reason that young people reject engineering careers. Engineering has a reputation as being a difficult and demanding educational choice with limited rewards.

—John Densler

GOING CASHLESS

In August, Associate Editor Monica Rozenfeld wrote about the economic benefits of digital payment systems, including the billions of dollars governments could save by no longer printing and transporting money, as well as making it more difficult to get away with certain crimes. Some readers had concerns.

Hasn't ransomware extortion become one of the top categories in cryptocurrency payment? Going digital is no assurance that fund transfers will involve only legal goods and services.

—Kelly Manning

For these types of payment systems to work, the communications systems they use must be reliable—which is not always the case. A few years ago I went to the gas station to fill up my tank and its electronic payment system was having a problem. As a result, there was a long line of people trying to pay. I had no problem—I just paid cash and did not need to wait.

—donb

A cashless society can lead to absolute control of the population. Do you trust the government that much? I sure don't. If you get on the government's blacklist for any reason, your accounts can be shut down, and you will become helpless and bankrupt. It's an Orwellian, police-state nightmare. There is also no recourse when the power goes out or the Internet is shut down. I have had no problems with my (mostly) cash-based lifestyle, and I intend to maintain my right to exchange value for value, without the use of electronics.

—Don Alexander

POKÉMON GO

In "Could Augmented Reality Games Have a Positive Impact?" Senior Editorial Assistant Amanda Davis questioned whether the game adhered to AR expert John Rousseau's proposed "laws of mixed reality," in which the technologies must increase mindfulness, create a shared human experience, and respect the lines between commerce and data.

By developing AR games like this one, we are trying to solve a problem by introducing a new one. When I see people walking around looking at their phone screen instead of the sidewalk, I fear for mankind's future.

—William

I have a teenage son who used to live for his PS4 game console, and now he spends time with his friends roaming the parks and town square searching for these Pokémon creatures. I believe the benefits of this technology currently outweigh the negatives, but I am also cautious of how it opens our children to commercial exploitation.

—Neal Murray

DANIEL HERTZBERG; PIXABAY

THEINSTITUTE.IEEE.ORG

Stepping Twice Into the Same Stream

Lessons from IEEE's past inform our future

BARRY L. SHOOP IEEE PRESIDENT AND CEO

IN MY September column, I began with a quote from the Greek philosopher Heraclitus of Ephesus, who reminded us "everything changes and nothing stands still ... and you cannot step twice into the same stream." Heraclitus was right. Not only because the stream changes; the person changes as well.

This also applies to organizations like IEEE. We have changed in the decades since our founding. So has the world and the professions we serve. We began as an organization founded and led by some of the leading industrial figures of the time. Over the years, we have become an indispensable partner to engineering professionals in academia and in the research and development community, but we have lagged in our relevance to industry professionals.

For IEEE to stay true to its promises, possibilities, and achievements, we must return to our roots. It is imperative that IEEE reconnect with those driving the advancement of technology in industry and entice these valued professionals back into our community. IEEE is at its best when we bring together the totality of our offerings with the rich diversity of our global community of professionals from academia, government, and industry to solve the problems facing humanity.

As stewards of IEEE's future, we ignore our past at our peril. The number of IEEE members who count industry as their employer has been declining. Since 2000, the percentage of IEEE members from industry has dropped from roughly 60 percent to 39 percent. Our content is losing relevance for those in industry, as it has become progressively more academic. Our career-development efforts are not optimally aligned with emerging industry needs. As an organization, we are at a crossroads, and IEEE has a choice to make.

DARREN CARROLL

NEW STEPS, NEW STREAMS

These past few years have seen great strides in IEEE's efforts to engage with industry, coupled with an urgency to provide technical professionals the tools and information they need to excel. The IEEE Ad Hoc Committee on Industry Engagement, led by IEEE Fellow Dejan Milojicic, and the entire IEEE Board of Directors have demonstrated vision and dedication in their efforts during the past two years to move IEEE forward. We are interacting extensively and diversely with industry to bring forth products and services of value and importance to technical professionals in industry.

> *IEEE's progress in reengaging with industry must continue*

Last year we met with more than 175 industry leaders from 45 companies in China, Germany, Japan, and Silicon Valley. This year, we met with 250 leaders from 47 companies in Canada, China, India, Israel, Japan, Singapore, South Korea, Taiwan, and the United States. Our goal was to collect feedback on IEEE's current offerings to industry, identify needs, and develop strategies to best serve industry professionals.

And we have begun taking steps to address the value proposition of IEEE membership to industry. One new product that serves the engineering community is IEEE GlobalSpec's Engineering360 information and collaboration platform. It provides first-rate content about electronic components straight to the desks of today's engineers. In addition, we established InnovationQ Plus through a partnership with IP.com that combines a powerful platform and IEEE content with IP.com's global patent and non-patent literature to aid innovators around the world.

We are opening application programming interfaces for the IEEE Xplore Digital Library to enable personalized experiences based on second-generation analytics. These APIs allow IEEE customers and third parties to query the IEEE Xplore content repository and retrieve results for manipulation and presentation on local Web interfaces. We can deliver highly relevant content and progressively evolve intelligent personal assistant capabilities.

Additionally, we are exploring the creation of an IEEE industry awards program and looking for ways to better recognize industry professionals through our Fellows Program. We are developing papers on technical trends that highlight the key technologies shaping the world around us and influencing the daily working life of IEEE members.

A major new initiative, the International Roadmap for Devices and Systems will ensure alignment and consensus across a range of stakeholders to identify trends and develop the road map for all related technologies in the computer industry. With the launch of the IRDS program, IEEE is taking the lead in building a comprehensive, end-to-end view of the computing ecosystem, including devices, components, systems, architecture, and software.

Our progress in this important area must continue. IEEE is accomplishing more, in a variety of pursuits, than our founders would have dreamed possible in 1884, or even in 1963, when our two forerunner societies merged to form IEEE. We are able to do this because IEEE, as a community, knows the best future is the one we build for ourselves, one in which the needs of all technical professionals—in academia, government, or industry—are not only addressed and met but exceeded.

I welcome your perspectives or suggestions on additional opportunities for IEEE to better serve our industry members. Please send your input to president@ieee.org. ◆

BENEFITS

More to Explore in Digital Senses

BY **AMANDA DAVIS**

IEEE offers a variety of resources to help you get up to speed on augmented reality, virtual reality, and human augmentation—the use of technology to enhance and improve our senses.

WEB PORTAL

The IEEE Digital Senses Initiative's Web portal contains information on conferences, projects, publications, and standards related to AR, VR, and human augmentation.

PUBLICATIONS

Starting next year, the quarterly *IEEE Consumer Electronics Magazine* plans to have an annual special issue on AR and VR. The publication is inviting authors to submit papers by 15 December 2016. In addition, a special section on the IEEE Digital Senses Initiative will be included in the magazine's January issue.

IEEE Pulse, a bimonthly magazine published by the IEEE Engineering in Medicine and Biology Society, regularly features articles on virtual reality and advances in prosthetics. "Virtual Reality: The New Era of Rehabilitation Engineering," published in the May/June issue, explored VR-based technologies relying on multimedia, accelerometers, and sensory-feedback devices that can help people learn to better control prosthetic limbs and regain motor abilities after a stroke.

Another article in that issue, "New Prostheses and Orthoses Step Up Their Game," covered advancements in orthotic devices that help soldiers carry heavy loads, patients recover from a stroke, and the elderly retain mobility.

Those interested in VR and human augmentation can also check out the quarterly *IEEE Transactions on Haptics*, published by the IEEE Computer, IEEE Consumer Electronics, and IEEE Robotics and Automation

societies. The journal features articles on human-machine interaction, technologies that re-create a sense of touch, and virtual environments.

The IEEE Computer Society's Technical Committee on Visualization and Graphics advances research in AR and VR as well as in computer graphics and visual analytics. The committee publishes the monthly *IEEE Transactions on Visualization and Computer Graphics*, which has articles on visualization techniques, software, hardware, and user interfaces. The committee also sponsors the annual IEEE Virtual Reality Conference and the IEEE International Symposium on Mixed and Augmented Reality.

The IEEE Digital Senses Initiative is planning to launch *Digital Senses Technology Outlook*, an annual report on advances made in the three areas. Also in the works is *Guidelines and Recommended Practices for VR Storytelling*, which is expected to feature best practices to be followed by filmmakers and game developers creating VR content.

COMMUNITY-BUILDING

Members can join the IEEE Digital Senses Community to receive updates on the Digital Senses Initiative's developments, including upcoming events, courses, and standards. It's free to join—look for the community in the IEEE Memberships and Subscriptions Catalog (http://www.ieee.org/membership-catalog).

You can also find IEEE Digital Senses in IEEE Collabratec (http://ieee-collabratec.ieee.org) and on Facebook, LinkedIn, and Twitter. ◆
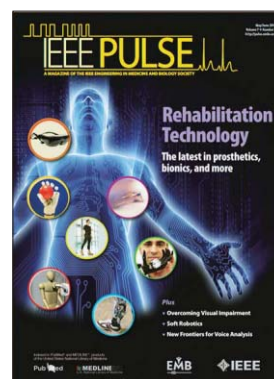
IEEE Standards Activities for Augmenting Reality

BY **KATHY PRETZ**

THE IEEE STANDARDS Association's (IEEE-SA) Industry Connections Program helps organizations working on rapidly evolving technologies incubate new standards and related products and services. Here are three activities in the works related to AR and VR.

■ The Augmented Reality in the Oil/Gas/Electric Industry activity considers how AR, as well as virtual reality and mixed AR and VR technologies, can benefit the three energy industries. Launched in June, the project helps identify related standards from IEEE and other organizations, and identify gaps in standards, as well. The project also is exploring how wearables, like head-mounted devices, could be applied in all three industries.

■ Formed in July 2015, the Smart Glasses Roadmap activity works to overcome hurdles to help accelerate the adoption of smartglasses across markets and applications. The activity is addressing user expectations and developing interoperability standards.

■ The presence of 3-D body scanners in retail clothing stores promises to bring a new level of immersion

to the shopping experience and provides consumers, through realistic and interactive visual representations, both a sense of style and a better view of how garments fit their bodies. Since January, the 3-D Body Processing activity has been developing standards for the capture and processing of scanned data and making certain that scanner technologies will communicate with one another. Standardization efforts are under way to set format types and classifications; quality specifications and metrics; test methods; communication, sharing, and security protocols; and privacy guidelines.

You can find more information on AR and VR standards activities on the IEEE-SA Industry Connections Web page at http://standards.ieee.org/industryconnections.

ISTOCKPHOTO

Conferences Focus on Technologies for AR and VR

Upcoming events delve into immersive projection technology, virtual storytelling, and navigation in virtual environments

International Digital Senses Conference and Expo

BEIJING; 6–8 MAY

TOPICS: Virtual and augmented reality applications for entertainment and gaming, theme parks, education, home decorating, sports, film, medical treatment, smart grid, emergency rescue, military, aviation, logistics, water conservation, and transportation.

SPONSOR: IEEE Digital Senses Initiative
VISIT: http://www.lookvrar.com

■ IEEE International Conference on Consumer Electronics

LAS VEGAS; 8–10 JANUARY

TOPICS: AR and VR technologies, entertainment and gaming systems, wireless and networking technologies, automotive systems and electronics, Internet of Things (IoT), sensors, and microelectromechanical systems. Held in conjunction with the Consumer Electronics Show, the theme of this IEEE conference is "Virtual and Augmented Lifestyle."
SPONSOR: IEEE Consumer Electronics Society
VISIT: http://www.icce.org

■ IEEE Virtual Reality Conference

LOS ANGELES; 18–22 MARCH

TOPICS: Input devices for VR and AR, advanced display technology, immersive projection technology, haptics and audio, modeling and simulation, VR and AR graphics techniques, navigation in virtual environments, telepresence robots, and interactive storytelling.
SPONSORS: IEEE Computer Society and IEEE Visualization and Graphics Technical Committee
VISIT: http://www.ieeevr.org/2017

■ Augmented World Expo

SANTA CLARA, CALIF.; 1–2 JUNE

TOPICS: The societal impact of AR and VR, wearables, smart textiles, smartglasses, virtual storytelling, AR for urban environments, education and health care applications, smart cities, and brain-machine interfaces. Exhibitors include representatives from the IEEE Standards Association.
SPONSOR: AugmentedReality.org
VISIT: http://www.augmentedworldexpo.com

■ Consumer Electronics Show Asia

SHANGHAI; 7–9 JUNE

TOPICS: VR applications, IoT, wearables, connected and autonomous vehicles, robotics for education, drones, sustainability trends in consumer electronics, smart home technologies, and 3-D printing. Exhibitors include representatives from the IEEE Digital Senses Initiative.
SPONSOR: Consumer Technology Association
VISIT: http://www.cesasia.cn

STARTUP

Investing in an Augmented World

A venture capital firm backs AR startups

BY **MONICA ROZENFELD**

Ori Inbar, who produces the Augmented World Expo, was a keynote speaker at this year's event, held in June in Santa Clara, Calif.

IEEE MEMBER Ori Inbar says he wants to see a billion users adopt augmented reality technologies by 2020. To get there, he's lending a helping hand to entrepreneurs through Super Ventures, a venture capital firm he helped launch this year. It is providing US $10 million in funding focused on AR startups. Inbar and three other experts in the field partnered to provide the funds and to mentor the ventures to help them grow. As of early October, the firm had invested in eight companies.

Inbar was inspired to work in AR because of his children, he says. Instead of spending time outdoors as he did as a child, they watched television or played video games. Inbar wanted to find a way to meld virtual and real worlds to motivate them to go outside and engage with what's around them.

That led him in 2009 to start Ogmento, which developed AR games. Apple last year acquired the company—renamed Flyby Media—for an undisclosed sum. Another one of Inbar's ventures, AugmentedReality.org, is a nonprofit organization that aims to advance the field. It produces the international Augmented World Expo conferences, the largest in the field.

"Augmented reality can help people perform significantly better in anything they do," Inbar says. "The technology essentially either enhances their abilities or equips them with new ones."

A PIECE OF THE PIE

Super Ventures typically invests about US $100,000 in each startup in return for a 5 percent equity, but the numbers can vary depending on the startup's needs and how far along it is in developing its product or service.

The firm's portfolio includes Fringefy, a company in Israel that's developing a local visual-search app for mobile devices including wearables. App users point their smartphone (or look with their smartglasses) in the direction of, say, a historic building, and written details about the landmark pop up on their device. Or if they point it at a restaurant, reviews appear on the screen. The app integrates GPS and custom computer vision software to detect what the user is pointing to or looking at.

Another venture, Waygo, is a translation app. Users point their smartphone at signs, menus, or other text written in Chinese, Japanese, or Korean, and the words are translated into English. Waygo employs optical character recognition and machine-learning software.

Inbar says that now is the ideal time for startups to break into AR, noting that the technology has advanced a great deal since he began.

When he launched Ogmento, his goal was to create AR games similar to Pokémon Go. But the consumer market wouldn't buy; mobile devices were not advanced enough. AR companies shifted their focus to industrial applications, where they found traction. Ogmento eventually changed its name to Flyby Media and repositioned itself to develop 3-D tracking technologies.

Google incorporated the technology into its Tango project, which allows developers to build apps that make use of 3-D spaces. For example, with Tango MeasureIt, if you are unsure whether a bookcase will fit in your office, take a photo of it and the app will display its measurements.

A NEW INDUSTRY

Now that mobile devices have caught up to the potential of AR, which is becoming mainstream, "the growth of these technologies is inevitable," Inbar says. He calls AR "the new wave of computing—we're inventing as we go along."

In 2010, to help move the field forward, Inbar launched the first Augmented World Expo. The conferences now take place annually on different continents, including Asia, Europe, and North America, to promote the technology and educate tech people through training seminars and mentorships on how to break into the field.

AUGMENTED WORLD EXPO

One area of focus is figuring out the best way for people to interact with AR technology. For example, although smartphone apps have helped introduce AR, Inbar says phones are not the best devices for the technology.

"Holding a phone in front of your face can feel awkward," he says, "and the field of view on the screen is narrow." He sees smartphones as "a great stepping stone" but predicts that people will eventually prefer to use smartglasses. With their hands free, he says, wearers will be able to interact with their environment in a more natural way.

Once people start experiencing AR in everyday life, it might be hard for them to stop, Inbar continues. As the adoption rate grows, he anticipates that companies and their investors will flock to AR. "Those who wait will have to play catch-up," he says. "The window of opportunity is closing."

Many innovations remain to be made, he says. For example, he's anticipating chips equipped with computer vision capabilities to make AR systems not only faster but also more precise and realistic. In addition, he says, smartglasses and other wearables need to become more user-friendly. Better sensors and software that can map environments in 3-D are needed as well.

"A lot of building blocks are still to be developed to drive this new wave of innovation," Inbar says. "There's an opportunity to become a leader in this space and take a big chunk of the market." ◆

PROFILE

Yu Yuan: Working to Build a Better Virtual Life

BY **KATHY PRETZ**

IEEE SENIOR MEMBER Yu Yuan, who chairs the IEEE Digital Senses Initiative, believes so much in the benefits of virtual reality, augmented reality, and human augmentation technologies to enhance and extend people's sensory capabilities that he's devoting his life to helping advance them. In April he launched Senses Global Corp. in Shenzhen, China, to focus on these three areas.

Senses Global is not Yuan's first startup. He launched two others after he left IBM Research in Beijing in 2013. As an IBM research scientist for nine years, he worked on the Internet of Things, intelligent transportation, and consumer electronics.

He's an active IEEE volunteer and a member of the IEEE Standards Association (IEEE-SA) Standards Board. He has chaired several IEEE standards working groups including one on drones and another on 3-D printing. He is also associate editor of *IEEE Consumer Electronics Magazine*.

For the past 17 years Yuan has dabbled in virtual reality, and he holds several patents relevant to AR and VR technologies.

"As a strong believer in the potential of VR and AR, I kept an eye on them," he says. "They can create new worlds where people can virtually live and play."

What sparked your interest in VR?
I was inspired by several science-fiction movies, especially *The Matrix* and *The Thirteenth Floor*. They're one of the reasons I got into VR in 1999.

YU YUAN

For me, real reality, if we can call it that, can be boring. Many of us want something different and more exciting, and I believe VR is the technology that can provide everyone with a much better life experience. It can create new worlds for each of us that will be even more exciting than what we see in the movies. VR will also be a fundamental game changer for many industries, and very soon.

That's why I've made it my life's mission to advance the fields. In my previous job, I was not close enough to this mission. But in running a VR company, I'm part of an exciting industry, and an inventor and developer.

What will your startup focus on?
We are building our intellectual property portfolio in the areas of VR, AR, and human augmentation technologies. Senses Global will also serve as an integrator and broker. We help other tech companies, especially those at the startup stage, to find partners, clients, and investors.

My company also joined the IEEE-SA as an advanced corporate member—as a way to participate in standards development and build relationships with other companies. I understand the importance of collaborating with others.

What are some concerns being raised about the three technologies?
For AR, it's protecting one's privacy. Google Glass was a well-known but unsuccessful AR product in part because people felt their privacy was

being invaded by those wearing the glasses. They especially raised concerns about their activities being recorded. These are the same issues with consumer AR helmets outfitted with smart goggles.

As for VR, because it is a completely immersive environment, the concern is similar to that expressed about online games: Children and young people could become so addicted that eventually they may not be able to distinguish between virtual life and real life. But VR could also help people who have a poor quality of life. It could allow them to live in a virtual world that makes them feel happier.

Human augmentation technologies, such as implants, exoskeletons, and prosthetics, are already helping people with disabilities live better and workers perform better. A concern here is not letting others know you have augmented your body with, for example, a brain-machine interface or an implant. Performance will be enhanced, except it won't be with drugs, like anabolic steroids, but with technology.

Altering humans also presents ethical, political, and, should the augmentation fail and create problems, legal risks that must be considered.

What are some of the challenges you're facing?
Fundamental challenges for AR include not only making

virtual objects look real but also allowing smooth interactions between virtual objects and real things. For example, a virtual object thrown against a real wall should cover the wall appropriately as it reaches the wall and bounces back.

Developers are solving this problem with SLAM [simultaneous localization and mapping], a series of complex computations and algorithms that employ sensor data to continuously scan and learn about the environment. At the same time, a person should also be able to augment the environment with useful digital content—which depends on the person's location in the space.

Eye-tracking technologies are also being applied to understand in which direction or at which object a person is looking. This could allow for fine-tuning in both the pictures being rendered on the head-mounted display and the interactions between the objects and the person.

The grand challenge for VR is to mimic human senses. Developers are doing fairly well with sight and hearing, but touch, smell, and taste are far from perfect. A perfect immersive virtual world won't be created until we learn how to use non-invasive or even invasive brain-machine interface technologies to mimic all the senses perfectly. ◆

OF NOTE

Recognize an Innovator

Nominate a colleague for IEEE's highest awards BY **LYNN FRASSETTI**

EACH YEAR IEEE pays tribute to technical professionals whose outstanding contributions have made a lasting impact on technology, the engineering profession, or humanity. The IEEE Awards program seeks nominations annually for IEEE's highest-level awards—Technical Field Awards, Medals, and Recognitions—which are presented on behalf of the IEEE Board of Directors.

The Medals and Recognitions are presented at the IEEE Honors Ceremony. The 2017 event is scheduled for 25 May at the Palace Hotel in San Francisco, in conjunction with the IEEE Vision, Innovation, and Challenges Summit.

You don't have to be an IEEE member to receive an award or to nominate or endorse a candidate. Nominations for 2018 Technical Field Awards are due 15 January, and

Medals and Recognitions are due 15 June. These are annual deadlines.

The IEEE Awards Board has an ongoing initiative to increase diversity among candidates considered for IEEE Technical Field Awards, Medals, and Recognitions, including their technical discipline, geography, and gender. The board also is working to ensure a diverse group of volunteers is on all the selection committees. You can help by nominating a colleague for one of the following awards.

IEEE MEDALS AND RECOGNITIONS

IEEE Medal of Honor
For an exceptional contribution or an extraordinary career in the IEEE fields of interest.
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IEEE Alexander Graham Bell Medal
For exceptional contributions to communications and networking sciences and engineering.
SPONSOR: Nokia Bell Labs

IEEE Edison Medal
For a career of meritorious achievement in electrical science, electrical engineering, or the electrical arts.
SPONSOR: Samsung Electronics Co. Ltd.

IEEE Medal for Environmental and Safety Technologies
For outstanding accomplishments in the application of technology in the fields of interest of IEEE that improve the environment and/or public safety.
SPONSOR: Toyota Motor Corp.

IEEE Founders Medal
For outstanding contributions in the leadership, planning, and administration of affairs of great value to the electrical and electronics engineering profession.
SPONSOR: IEEE Foundation

IEEE Richard W. Hamming Medal
For exceptional contributions to information sciences, systems, and technology.
SPONSOR: Qualcomm Inc.

IEEE Medal for Innovations in Healthcare Technology
For exceptional contributions to technologies and applications benefiting healthcare, medicine, and the health sciences.
SPONSOR: IEEE Engineering in Medicine and Biology Society

IEEE Jack S. Kilby Signal Processing Medal
For outstanding achievements in signal processing.
SPONSOR: Texas Instruments Inc.

IEEE James H. Mulligan, Jr. Education Medal
For a career of outstanding contributions to education in the fields of interest of IEEE.
SPONSORS: MathWorks, Pearson, and the IEEE Life Members Fund

IEEE Jun-ichi Nishizawa Medal
For outstanding contributions to material and device science and technology, including practical application.
SPONSOR: The Federation of Electric Power Companies, Japan

IEEE Robert N. Noyce Medal
For exceptional contributions to the microelectronics industry.
SPONSOR: Intel Foundation

IEEE Dennis J. Picard Medal for Radar Technologies and Applications
For outstanding accomplishments in advancing the fields of radar technologies and their applications.
SPONSOR: Raytheon Co.

IEEE Medal in Power Engineering
For outstanding contributions to the technology associated with the generation, transmission, distribution, application, and utilization of electric power for the betterment of society.
SPONSORS: IEEE Industry Applications, IEEE Industrial Electronics, IEEE Power Electronics, and IEEE Power & Energy societies

IEEE Simon Ramo Medal
For exceptional achievement in systems engineering and systems science.
SPONSOR: Northrop Grumman Corp.

IEEE John von Neumann Medal
For outstanding achievements in computer-related science and technology.
SPONSOR: IBM Corp.

IEEE Honorary Membership
To individuals not members of the IEEE who have rendered meritorious service to humanity in IEEE's designated fields of interest.
SPONSOR: IEEE

IEEE CORPORATE RECOGNITION

IEEE Corporate Innovation Award
For an outstanding innovation by an organization in an IEEE field of interest.
SPONSOR: IEEE

IEEE SERVICE AWARDS

IEEE Richard M. Emberson Award
For distinguished service advancing the technical objectives of the IEEE.
SPONSOR: IEEE Technical Activities Board

IEEE Haraden Pratt Award
For outstanding volunteer service to the IEEE.
SPONSOR: IEEE Foundation

For help with submitting a nomination, such as award criteria, candidate eligibility, and submission guidelines, visit http://www.ieee.org/about/awards/awards_guidelines.html. For a list of the top IEEE awards, including Technical Field Awards, and to download nomination forms, visit http://www.ieee.org/awards. Questions? Email awards@ieee.org or call +1 732 562 3844.

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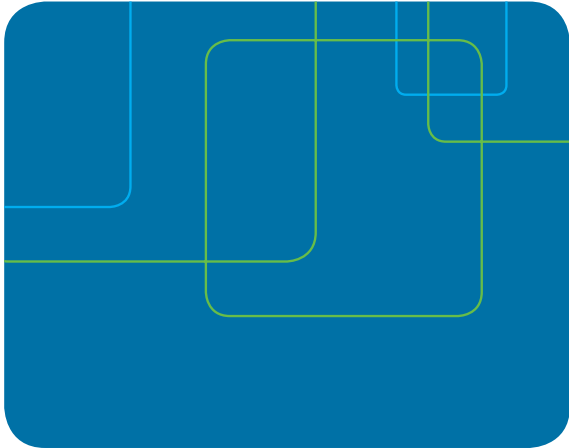
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