LOOK before you leap. Think before you act. These and other pieces of good advice are all about what you can see before you decide what to do. Lately, there are more input types and data sources coming into everyone's eyeballs that can help human activities, including process control and automation. However, the problem is sorting through new formats like augmented reality (AR) and others, choosing the most suitable, organizing what they're trying to say, and using them to achieve better outcomes.

Virtual training, real savings

"The semiconductor industry is going through a major transformation," says Dr. DP Prakash, global head of innovation in the CIO division at GlobalFoundries (www.globalfoundries.com) in Santa Clara, Calif. "First, growing demand for product mixes comes with an associated rise in manufacturing complexity. Second, as we approach quantum limits on how small microprocessors can go, Moore's Law scaling is fading out. Productivity improvements through innovative technologies including machine learning, artificial intelligence (AI), virtual reality (VR), AR and robotic process automation are more important than ever."

Prakash reports that demonstrations on the potential value of enterprise AR by PTC (www.ptc.com) inspired GlobalFoundries to pursue it. "We were convinced AR and VR will improve employee safety, training and productivity," he says. Prakash adds AR can deliver value in four primary areas, and that GlobalFoundries is exploring and integrating all of them. They include:

- Documentation that's simpler and 10 times faster with AR headsets and software because maintenance workflows can be captured quickly by experts, edited rapidly, and pushed to a cloud-computing service.
- Training by projecting digital displays on plant-floor equipment to supplement classroom instruction, which can cut training time in half.
- Operations with voice-activated AR allows quick access to the right data at the right time, reducing cognitive-load errors.
- Analytics for predictive and proactive maintenance before manufacturing tools and process applications experience problems or shutdowns.

Get the picture

Augmented realities extend visibility for performance and profit

by Jim Montague

Following recent pilot projects, GlobalFoundries enabled all its factories with Vuforia Expert Capture AR software and Vuforia Engine training software from PTC. "Now, Vuforia helps us capture all that content on the RealWear or Microsoft HoloLens headset, edit, organize and redeploy it wherever it's needed," adds Prakash. "We've already cut training time by 50%."

AR = HMI + digital twin

If potential users find 3D graphics floating in front of physical equipment disorienting, it may help to think of AR is as a natural extension of the human-machine interfaces (HMI) that came before. Just as paper and clipboards gave way to display panels, PCs, tablets and smart phones, today's screens are giving way to headsets, glasses and other screen-less displays, but the basic data delivery mission of all these HMI formats remains the same. The twist now is AR's flexibility allows data, models and digital twins to be added to interfaces for more efficient responses.

Ken Adamson, vice president for PlantSight at Bentley Systems Inc. (www.bentley.com), adds that, "A digital twin is virtual information that reflects what's physically there, so it must be continually updated, and bring new data to the model from different sources like spreadsheets. The other side is AR with most whiz-bang examples putting 3D pictures on the real world, but it can use any type of data on top of the model, and show it in a real-world context. We're calling AR 'visual operations' because it superimposes data on real items, including video feeds to headsets and hardhats, so users can work hands-free. Another benefit of AR is it can integrate 3D models into reality models to show processes that usually can't be seen, such as pipes underground or wiring behind walls."

Some pictorial history

While AR, virtual reality (VR), mixed reality (MR) and fill-in-the-blank X reality (XR) are getting plenty of attention lately, they're based on 3D graphics and display technologies that have been around for many years. First-person, videogame-style, walk-through simulations were expected to take over about 10 years ago, and made headway in some industries, but they mostly

DATA-AIDED REALITY

Figure 1: iQagent software scans QR codes and other points of interest (POI), links with a server via wireless, and calls up real-time operating data, documents, video and other resources about the equipment it's viewing on tablet PCs, smart phones and wearable devices. Source: iQagent

came and went in process applications because they didn't achieve widespread implementation.

"In 2008, we started working with first-person gaming software, and using 3D graphics to show real-time SCADA data. Now, more use cases have emerged, including using building information system (BIM) software like Autodesk's Revit for 3D simulation and walkthroughs," says Russ Agrusa, president and CEO of Iconics (iconics.com), now part of Mitsubishi Electric Corp. "Different industries adopt AR at different rates."

Agrusa reports one of AR's primary advances is how it can perform object recognition using stored device types or barcodes, QR codes or tags on equipment, and use that recognition to superimpose physical images with graphics showing documentation, manuals, operations, or other useful information. "A tank can be overlaid with images showing status, contents and flows. All these elements can appear in the user's field of view, right on top of the physical equipment it represents, which is more efficient than calling back and forth to a control room on a walkie-talkie, or even looking at a regular tablet PC," adds Agrusa. "We're going to see a wave of innovation over the next five years, and just as we moved from PLCs to PCs and the Internet, AR is the next step for interfaces. For example, AR can be used with facial recognition or biometrics for improving security or audit trails. It can also work with global positioning systems (GPS) to deploy the closest people to fix problems faster."

Bob Meads, CEO of iQagent (https://iqagent.com), reports his company and its AR software grew out of his 20-year-old system integration firm, iQuest (www.iquestcorp.com), which was established to develop software integration with Siemens Simatic WinCC HMI software. "When we saw the iPad 2 come out with its camera in 2011, we knew we wanted get it onto the plant floor quickly, and create something new. Our idea was to create an app that could recognize equipment and display relevant information," says Meads. "We bootstrapped our iQagent software, and launched in 2012 as one the first AR solutions to make relevant data and resources appear immediately on a mobile device, which in turn allows them to be more efficient." (Figure 1)

From the beginning, Meads reports AR was intended to put digital information into the context of the real world. However, to provide data, AR systems needs to know where:

- Users are located in a facility;
- Equipment is situated on the plant floor, and what other devices are in the same area; and
- Sensors and instruments are oriented, and how their data will be captured and visualized.

"We started with QR and barcodes to create points of interest (POI) because they were more efficient and cheaper than using algorithms for object recognition," explains Meads. "Now, devices like Microsoft HoloLens can map an environment, and add information about the devices in it via a wireless network. Users can see what's happening where they're at, and view data just like seeing the POIs that show up in Google Maps. They can also run iQagent on RealWear headsets if they need to be hands-free."

Seeking use cases

Even though AR is still in the early adopting phase in the process industries, its supporters report there are many use cases where it can assist process operations.

"Because there are so many ways that AR/VR and mixed reality can be applied, users must start by identifying a business problem, a pain in the neck, or just information that needs to be collected to help decide what AR or other solution to use," adds Bentley's Adamson. "Because AR can use data from the cloud, it can do fleet-level functions by capturing real-time data from many assets or facilities in varied environments that need an assist at the local level.

"For example, Shell is building a 450-acre chemical plant near the Ohio River and Pittsburgh. It's contracted with Eye-bot solutions to fly over the site twice a week, using drones and our reality modeling software to track construction and check for unsafe situations. Shell is also using our flood simulation software with the continuously updated reality model to determine what would be impacted first, and show pooling after heavy rains to indicate if any equipment needs to be moved."

Dave Skelton, vice president of development and manufacturing at Phoenix Contact (www.phoenixcontact.com), reports it's developed and demonstrated two pilot AR applications, one for managing compressor controls on shrink-sleeve equipment at its U.S. headquarters in Harrisburg, Pa. and the other providing visualization of control assets at point of installation in Building 4 on its campus in Bad Pyrmont, Germany.

"The project in Germany retrofitted the facility, using the Niagara protocol platform on the PLCNext controller, which in-

terfaced multiple protocols like Profinet and Modbus," explains Skelton. "The project allowed the combination of control of multiple control platforms found, not only traditional HVAC, but all energy, security, fire protection and lighting controls. AR was used to show the maintenance staff maintenance drawings and safety procedures, using targets on their control cabinets.

"In Harrisburg, the technology project originally connected our PLCnext to the cloud for data collection, but the team also used AR to display information. It was immediately apparent that AR could quickly show indicators for machine cycles, performance history, voltage/current flows and energy use, and serve on a HoloLens to visualize values for operations at the machine (Figure 2). It can also show the equipment's accessible work range, and if it's in or out of work range. Recommendations if it's out of range, such as how to fix it and what parts might be needed, are future additions being considered. This was big for maintenance because AR can show information that doesn't have to be searched for anymore."

Matt Klinepeter, lead web developer at Phoenix Contact, reports that live production data is shown on the HoloLens, but first it's read into a Node-RED-to-HTTP server that's hosted on the PLCNext controller. This system is networked using regular HTTP protocol, but it's programmed to provide data by C# software and a list of API dependencies.

Remote monitoring—and mentoring

Beyond bringing in and showing production data more efficiently, AR's other advantage is it can connect field workers with more experienced personnel, who can see exactly what the field person sees, even though the remote expert is at a distance.

REACHING FOR PERFORMANCE

Figure 2: Noah Greene, mechatronics apprentice at Phoenix Contact, uses a Microsoft HoloLens to demonstrate an AR-aided pilot for compressor control, and see indicators like performance history and energy use much faster. Source: Phoenix Contact

"AR isn't used in many process industry applications yet, but one of its biggest uses is in remote mentoring, mostly in oil and gas facilities," says iQagent's Meads. "A mentor can see through the field operator's camera, so they're both looking at the same things in the same view. The mentor can draw in the operator's field of view or pull up a document, so they can collaborate on how to correct the issue."

Meads adds iQagent AR software runs on HoloLens, as well as on iOS devices using ARKit for compatible iPad and iPhones. "These applications can help users with maintenance and

DEFINING REALITIES

Plenty of new, old, familiar and semi-understood terms get tossed around in discussion about augmented and related realities. To get observers, developers and potential users on the same page, here are some consensus definitions of the most common terms:

- Augmented reality (AR) usually consists of digital 3D, CAD/CAM or other computer-generated graphics superimposed on images of physical equipment, production applications or other real-world environments. These graphics and their support software typically recognize physical items, or barcodes or QR codes on them, and provide supporting documentation, operating status or other useful data.
- Virtual reality (VR) is typically complete immersion of the viewer in a computer-generated environment that doesn't include real-world images or video, but has been used to simulate some physical operations or environments.
- Mixed reality (MR) combines elements of AR and VR, working in a real-world environment with non-real objects. For example, because users typically see the outside of a device but not inside, MR lets them work on it by allowing them to view a digital rendering of its insides.
- X reality (XR) joins AR, VR, MR and physical reality to whatever proportion each is needed by users and their applications.
- Digital twin begins with a description of a physical device or system, which becomes increasingly complex until a model is developed that represents as many of the real item's characteristics as possible. This lets users input data, parameters and potential problems into the twin, test scenarios much faster then could be done in reality, show how the real-world counterpart will likely respond or operate, and make adjustments that can optimize the real device or system.
- Simulation includes using prior performance data or benchmarks, projecting what will happen in the future, and making proactive adjustments. These have progressed in sophistication and decreasing turnaround time from written reports to increasingly dynamic computerized and digital versions that can run in near-real-time to the processes they're simulating.

changeovers, which often require dozens of procedures to be followed," explains Meads. "Instead of using the traditional dozen printouts for changeover, AR lets users pull up the right procedure on a wearable device, including images and videos, make that information available in context, and walk users through what they need to do."

Iconics' Agrusa adds that, "Remote experts can be whisperers that solve problems, but AR can also connect the few remaining process control gurus with new people that can learn from them more easily. AR improves collaboration because those process control gurus can write notes, point out parts of images, and circle items to convey their expertise to new employees in real time. Iconics has a Connected Field Service solution that integrates with our MobileHMI app and remote expert feature, which connects regular SCADA systems; allows them to run on smart phones, headsets, or eyepieces; brings up any related information (from documentation to videos); and fuses them all together."

Wearable = hands-free

Probably the most important technology aiding AR and enabled by it is the parallel emergence of wearable interfaces that can put data in front of workers, deliver remote expertise to users, and most importantly, free their hands at the same time.

HOW TO MAKE AR A REALITY

There are several essential steps needed to implement augmented, virtual or mixed reality solutions. Individual applications may need others, but here are the basic requirements:

- Identify the problem or use case that AR can help solve;
- View online videos or other presentations of the various AR, VR and MR technologies in use to learn how they function.
- Play with any readily available AR/VR or wearable devices, such as Microsoft HoloLens, Google Glass, Oculus Rift or others. This can be help users explore how AR/VR works, and show where they might be most useful.
- Determine if the process application where AR/VR could be used is indoors or outdoors, which can affect which technology to employ.
- Decide if the AR/VR user can use a hands-on device such as a tablet PC, or if they need a hands-free or voice-activated device such as a wearable headset.
- Evaluate what information should be presented on the AR/VR device and how it will be delivered, such as documents, manuals, real-time signals and SCADA.
- Decide what remote expertise may be needed by field staff, and determine the best AR solution for connecting them.
- Design and develop an AR pilot that solves problems identified earlier, gather return on investment (ROI) data, and scale up after pilot proves itself.

For instance, Braskem Idesa (www.braskemidesa.com.mx) makes more than 1 million tons of polyethylene annually at its three-year-old plant in Nanchital, Mexico. Its products are made from ethane using a potentially risky process involving pressures up to 3,000 (45,000 psi). To improve performance and reduce risk using digitalization, machine learning, and predictive/prescriptive maintenance, Braskem personnel undertook a project called Cyclops that uses wearable, AR-enabled, Connected Plant headsets from Honeywell for two-way sound and video communications. They're supported by a three-year subscription for software, applications and services for Connected Plant wearables. The AR headsets provide task automation to workers, who receive guidance, and can visualize system information and documents to correctly perform tasks. They can also get assistance from experts, who can access each user's head-mounted display camera and use video chat to offer advice.

"Cyclops began after I talked with Honeywell about scenarios as I worked with the plant on startup in 2016," says Marco Santos, production engineer at Braskem Idesa. "My concerns were focused on the operators. We had cell phones, laptops and the DCS, but in the field, no tools for operators, just pencil and paper to take data.

"With Cyclops, we're increasing reliability, productivity and operational skills, and monitoring startup and shutdown activities," adds Santos. "We can use the headsets to communicate and coach operators in real time. When we inspect raw materials, we can consult specifications. For safety, operators can take video evidence of unsafe acts and conditions, and report them in real time to other operators and supervisors."

In addition, the headsets also let experts guide staff using text and graphics, designate features that need attention, capture and annotate still images, and make text notes, Also, videos of field operations can be used as tutorials to teach new operators unfamiliar procedures. In the future, Santos adds the plant will implement Movilizer, which is a handheld system that guides and records operator and maintenance rounds, and uses intelligent vests for real-time monitoring of workers' vital signs and environmental conditions.

Guided to performance

Despite the potential gains, GlobalFoundries' Prakash reports it took a while to convince staffers to accept and get used to their new AR tools. "It's human to resist change, so we identified pain points, and showed how AR could help," explains Prakash. "We made it more about the business and use cases, and less about the new technology, and got a much better reception. For example, once they learned how AR could help their standard operating procedures, they came knocking and asking for it."

For users that want to implement AR, Prakash adds advocacy should come from the top, bottom and middle of any organization, just as it did at GlobalFoundries. "Leading a business transformation through AR is not an easy task, and it will be much

tougher for any organization without support from the CEO, CIO and other top managers. You have to get engagement at the top floor early on. Our CEO and CIO recognized the potential of enterprise AR to provide a quick return on investment (ROI) that led from the front," says Prakash. "Leadership on the plant floor is just as important because it has the people who are closest to the pain points and know the most about them. They just need to learn what AR can do and how it can deliver ROI across the four levels of value, including documentation, trainings, operations and analytics.

"Finally, middle managers, who usually focus on KPIs and other metrics and don't have time for innovation, need to be convinced. Our onsite Innovation Labs play a crucial role in this regard, where use cases with benefits can be demonstrated to leaders without disrupting operations. All GlobalFoundries' sites now have fully enabled labs, where new ideas are put to test with a culture of risk-taking, failing fast and learning quickly."

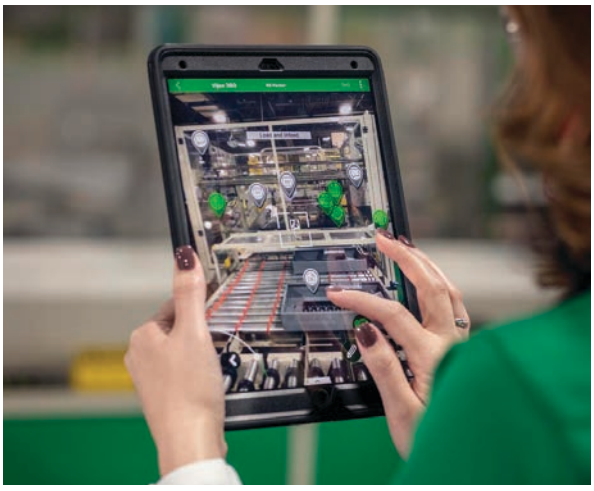
Augmenting analytics

Beyond its initial applications in training and maintenance, AR can help in other disciplines, such as keeping data close at hand, models updated, and analytics applicable.

"A couple of years ago, I'd have said, aside from the usual use cases around training and access to documentation, AR/VR was window dressing, but my position changed. AR can also be a major source of context and reinforce domain knowledge in analytic models. This also allows organizations to move forward with more consistent asset models," says Luke Durcan, director for EcoStruxure for North America at Schneider Electric (www.schneider-electric.us). "Many clients talk about wanting to use digital twins, but they don't really know what it means or where to start. I ask what asset register they're using, such as Wonderware, Maximo, SAP or manual documentation in a file cabinet, because they can turn this registry into the start of an asset model once they've enriched the data, and progress from there to a potential digital twin. However, these registers and models are usually fragmented across each organization, and they need to be more consistent to put data into context, so they can run higher-performing analytics."

Durcan reports users need consistent asset models that can correspond with time series data, which is the foundation of any data science or machine learning program. "However, data science is a new concept for many users, so they need consistent models and asset registers from which they can build digital twins," explains Durcan. "This is where AR can come in as the interface between plant floor and the digital infrastructure. Traditionally, an asset register might just be a document in a binder, database or online, but these can get lost, and if they're not continually updated, they'll lose their context, even if they're using software like Aveva APM, Maximo or SAP. It's not just the technology; it's the people and process that drive business value"

In short, AR/VR can give users the nudge they need to update their asset registers and models, as well as provide a consistent framework for adjusting applications and enabling patchworks of equipment to collaborate. "If a maintenance guy must keep his operation running, documentation is likely low on his agenda. However, if he can use an AR tool, such as our EcoStruxure Augmented Operator Advisor (AOA) software, then he might be able to do more documentation because it's easier. Moving forward, high-performance models are getting more complex, and using direct, ground-truth data feeds from devices back to models. AR can enable them by adding context, or allowing domain experts to better train data science models."



SEEING INTO CELLS

Figure 3: The 16 robotic cells at Schneider Electric's 50-year-old but newly revamped smart factory in Lexington, Ky., which makes about 11,000 load sensors per day using its EcoStruxure Augmented Operator Advisor (AOA) software to increase visibility into operations maintenance, achieved a 20% reduction in mean time to repair (MTTR) on equipment, and use process digitization to reduce paperwork by 90%. Source: Schneider Electric

For example, Schneider Electric runs 16 robotic cells at its 50-year-old brownfield facility in Lexington, Ky., which makes about 11,000 load centers per day for residential and industrial use and industrial safety switches. However, like any manufacturing environment machine breakdown could effect production especially as much of the plant is automated. As a result, Schneider Electric recently revamped the plant as its first U.S. smart factory by integrating EcoStruxure AOA, which increased visibility into operations maintenance, achieved a 20% reduction in mean time to repair (MTTR) on equipment, and used process digitization to reduce paperwork by 90% (Figure 3).

"The Lexington plant is using AR for training, compliance, and speeding up documentation for diagnostics," adds Durcan. "Unless it's part of a mandated process, a lot of data doesn't get saved, or if it's kept, it's only for an individual process and it's locked up. AR can change this by improving data access for asset models and operations." ∞