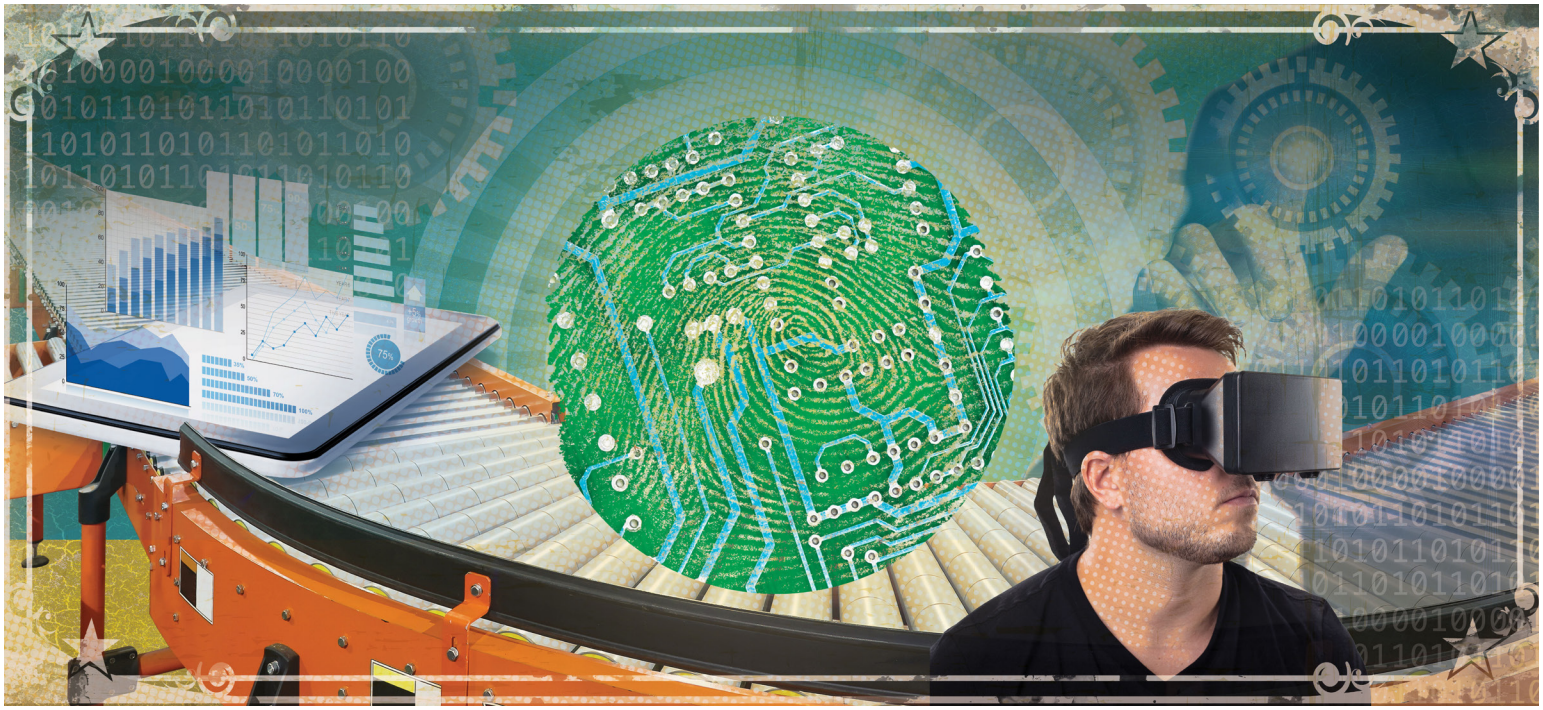

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Signals for Strategists

For more companies, new ways of seeing

Momentum is building for augmented and virtual reality in the enterprise

By Ryan Kaiser and David Schatsky

WEARING a computer screen on your face seems like something only a gamer or tech enthusiast could love. But headsets, and other devices that create mobile virtual or augmented reality experiences, are showing up in places other than labs and gaming centers. Big companies far outside the world of consumer entertainment are testing and deploying augmented reality and virtual reality (AR/VR) equipment in a wide range of work-related applications, and improving capabilities are inspiring more potential uses. The technology is getting so effective—and sufficiently user-friendly—that more companies should consider incorporating AR/VR solutions into their workflow.

Signals

- More than 150 companies in multiple industries, including 52 of the *Fortune* 500, are testing or have deployed AR/VR solutions[1]

- VC and corporate investment in AR/VR start-ups totaled $2.3 billion in 2016, an increase of 230 percent over the previous year[2]
- A consortium of 28 venture capital firms formed last year and pooled $10 billion for VR technology investment[3]
- New AR/VR hardware from at least five companies, including Microsoft and HTC, hit the market in the last year, with some of these products targeting enterprise use[4]
- Market researcher IDC projected worldwide revenue from AR/VR would grow from $5.2 billion in 2016 to $162 billion by 2020[5]

Enterprises are now exploring multiple applications of AR/VR

A growing number of enterprises—even those outside of gaming and other consumer entertainment subsectors—are testing and adopting AR and VR technologies.[6] Last year, Deloitte suggested that the time had arrived for enterprises to begin experimenting with the technologies. Many companies have since begun to test and deploy the technology, and our conversations with hundreds of executives have surfaced strong interest in AR/VR.

Our analysis of more than 150 AR and VR pilots and deployments suggests that they can be grouped into four categories.

GUIDANCE AND COLLABORATION

Workers in factories and warehouses, along with those who perform service in the field, can benefit from AR/VR devices that streamline workflow by providing access to hands-free information while completing a manual task, such as maintenance or repair. Smart glasses or head-mounted displays can overlay instructions, maps, system information, or real-time feedback over a worker's field of view. Some of these applications also offer the ability to collaborate with colleagues from remote locations who can see what the user sees and can guide him to troubleshoot any issues.

Guidance and collaboration applications can be found in sectors such as aerospace, process and discrete manufacturing, and oil and gas. The goal of these applications is to increase worker productivity or accuracy by reducing time spent accessing and cross-checking data, or consulting with teammates for advice. In some cases, productivity increased the first time workers used the technology.[7] Companies hope that the hands-free access to information and remote collaboration offered by AR/VR can reduce the risk of error, injury, or fatigue.

WHAT IS AUGMENTED AND VIRTUAL REALITY?

Virtual reality (VR) and augmented reality (AR) technologies have been around for quite some time,[8] yet many remain unclear about the differences between the two. We define these concepts as follows:

Virtual reality: a technology that allows a user to perceive and interact with a simulated environment. The environment may be either realistic or fanciful.

Augmented reality: a technology that overlays information onto a user's field of view as she perceives the real world. The information typically informs the user about an object or place at which she is looking.

Mixed reality: technically a subset of augmented reality, this technology enables the perceived merging of real and virtual worlds to produce new environments and visualizations in which simulated digital objects and information and real objects can co-exist and interact with one another.

Users experience AR/VR via a variety of types of hardware, including common mobile devices such as smartphones and tablets, smart glasses, and head-mounted displays. Smart glasses typically look like oversized spectacles and can either be monocular, in which information is displayed over one eye's field of view, or binocular, in which it is projected over both. Head-mounted displays are headsets designed to provide the most immersive experience possible. Some are tethered via wire to a physical computer to draw upon the immense computing power required to render immersive environments, which limits their mobility.

Examples of guidance and collaboration applications of AR/VR: A global logistics company's expanding smart glasses program, which guides warehouse pickers in assembling shipments, resulted in reduced error rates. Boeing engineers decreased wiring production time by 25 percent after replacing assembly manuals with smart glasses displays.[9] And GE is testing a "smart helmet" that enables technicians at natural gas plants to view instructions or receive remote assistance from their colleagues while performing maintenance tasks.[10]

IMMERSIVE LEARNING AND TRAINING

AR/VR also lends itself well to applications in education and training, including therapies that train patients how to cope with conditions such as post-traumatic stress disorder (PTSD), to manage their pain, and to engage in rehabilitation. For these applications, organizations generally employ head-mounted displays to immerse users in virtual environments that simulate real-life scenarios. We see exploration in health care and higher education and deployment in industrial and consumer products.

These applications may allow organizations to train staff at lower cost and reduced risk.[11] The technology may also help learners retain more information than traditional training methods: In one test, surgeons retained approximately 80 percent of training material presented via VR compared to 20 percent when listening to a lecture.[12]

Japan Airlines is experimenting with training co-pilots in a virtual cockpit.[13] California and Florida public schools have deployed VR to send students on virtual field trips,[14] medical schools are experimenting with teaching surgical techniques on simulated cadavers,[15] and University of Southern California researchers are exploring the technology's use in reliving traumatic memories to help veterans better cope with PTSD.[16]

Table 1. Applications of AR/VR technologies

Enterprise category	What	Where	Potential results
Guidance and collaboration	Provide a worker with visual cues to help her perform tasks such as maintenance, repair, or assembly	Aerospace and defense, automotive, construction, health care providers, industrial products, oil and gas, power and utilities, technology	Improved productivity, streamlined work processes, reduced risk, cross-geographic collaboration
Immersive learning	Immerse the user in realistic training environments that are normally either high-cost or high-risk to personnel; variations include addressing PTSD, phobias, and other medical issues	Consumer products, health care providers, higher education, and industrial products	Stronger retention of material, reduced risk, cost savings, improved therapeutic outcomes
Enhanced consumer experience	Enhance customers' experience by providing customized or unique methods to interact with the company, brand, or its products	Automotive, banking and securities, consumer products, health care providers, industrial products, media and entertainment, and travel, hospitality, and services	Better customer engagement, increased marketing opportunities, increased sales, enhanced brand positioning
Design and analysis	Enable knowledge workers to assess design ideas virtually and/or analyze data in new formats	Aerospace and defense, automotive, construction, higher education, industrial products, real estate, and technology	Cost savings, increased efficiency, earlier detection of design flaws, new methods to analyze data and generate insights

Source: Deloitte analysis.

ENHANCED CONSUMER EXPERIENCE

Innovative marketers are deploying AR/VR technology to enhance customers' experiences with their company, products, and brand, particularly in the adtech, martech, and commerce spaces, which some analysts expect will account for a significant share of AR/VR revenue over the long term.[17] Applications typically allow customers to virtually interact with brands to visualize and tailor products to their preferences. Companies exploring AR/VR for consumer experience can be found in the automotive, banking, consumer products, retail, and travel and hospitality sectors.

The benefits may include better brand positioning, more effective marketing campaigns, and fewer product returns. Some companies have seen sales boosts, particularly in e-commerce.[18]

One example of this application of AR/VR is Sephora's Virtual Artist tool, which allows consumers to sample makeup without physically touching the product. Using a customer's smartphone camera, the app can project various shades of makeup on an image or video of her face and will even stay in place if she moves the camera around.[19] Several real estate companies are experimenting with VR prototypes that allow customers to remotely view properties, both built and planned, more comprehensively than via online photos.[20] Other companies are boosting their marketing efforts by tapping into consumer-facing AR/VR applications, such as PokemonGo, to physically guide customers to the company's location, a strategy that has sometimes increased sales.[21]

DESIGN AND ANALYSIS

AR/VR is also enabling some companies to digitize the product-design process. Designers wearing headsets can now construct, model, and test products in realistically simulated environments, which enhances quality and accelerates design workflow. Sectors exploring AR/VR technology for design include aerospace, automotive, industrial products, real estate, and technology.

Because AR/VR enables designers to model and test detailed virtual prototypes without physical construction, it can cut development time, reduce production costs, and yield better products by increasing understanding earlier in the process. For example, BMW has deployed

VR to design and prototype virtual automobiles, making the design process faster and cheaper, while NASA is using AR/VR to design the next Mars Rover.[22]

AR/VR also brings greater insights into traditional workflow by providing enterprises with new techniques to analyze data. Citigroup developed a proof-of-concept virtual workstation to visualize trading trends and manipulate complex data sets within the user's field of view.[23] Fidelity Investments has a virtual-reality equity management tool that generates a 3D rendering of an investment portfolio.[24] Sectors testing new types of data visualizations include banking, higher education, investment management, and technology. As AR/VR technology evolves, data analysts will benefit from new types of analysis that will allow more intuitive graphs, better insights, and novel methods of communicating findings.

What to watch

As we've seen, a good number of organizations are already exploring enterprise applications of AR/VR. As the technology continues to improve, the case for testing, adoption, and deployment will become stronger. Here are some indicators that can help determine the right time to dive in.

Computational power: AR/VR requires substantial computing power to create high-quality graphics, reduce lag between a user's movement and the display's response, and increase the visual frame rate to more than 90 frames per second (FPS), a rate that won't

induce motion sickness. The development of dedicated processing units that can increase computing power and speed, while reducing power consumption, will allow AR/VR hardware to do more.

Battery life: Many guidance and collaboration applications will remain impractical until the batteries in AR/VR headsets can last an entire work shift—at least eight to ten hours. Most devices on the market currently last less than half that time. As battery life increases, so will the appeal of these applications.

Field of view: The human field of view can extend to approximately 180 degrees, the middle 114 of which is considered to be binocular in which humans use both eyes and can perceive depth and distance.[25] Although many devices have fields of view just higher than 100 degrees, increasing the field toward 180 degrees will expand a worker's observable environment and enable more immersive experiences.

Eye tracking: Many devices today already use gestures and voice commands, but advances in new eye tracking techniques, such as foveated rendering—which decreases system demands by tracking a user's eye and rendering only what he looks at versus the entire field of view—may soon reduce power consumption and increase the interface's responsiveness.[26]

New entrants and sensors: Some analysts predict that big names such as Apple Inc. and Samsung will enter the mobile AR market in the next one to two years.[27] If true, they could enlist an army of developers to create new content and, then, introduce new sensors[28] that could better track a user's location, gauge proximity to other objects, and perceive depth.

Price point: Most AR/VR hardware is still expensive, with costs ranging from several hundred to several thousand dollars per user setup. With many new technologies, price influences consumer adoption, and a decrease may drive enterprise adoption as well. As prices fall, expect enterprise experimentation and deployment to increase.

Comfort/weight: Some devices, weighing over a pound and uncomfortably bulky, can be tiring for workers to wear for an extended period. As lighter and sleeker devices become available, adoption will grow.

NUMEROUS OPPORTUNITIES IN THE ENTERPRISE

Companies that employ workers for maintenance, repairs, or inspections, particularly in remote locations, may want to explore integrating AR/VR technologies into their workflows. Providing workers with hands-free access to information and assistance from colleagues while they work promises to increase efficiency in sectors such as construction, manufacturing, logistics, and oil and gas.

Organizations that conduct high-risk or costly training in sectors such as aviation, medicine, and industrial products should also consider exploring AR/VR technologies. AR/VR training may lower the cost, reduce the risk, and increase the effectiveness of training to perform exacting physical tasks.

The time is also right for marketing leaders in consumer products, retail, and real estate to begin testing the technology for their businesses. As always, clear performance measures will tell the tale.

Many organizations have incorporated AR/VR into their design processes, but there is so far limited data about the impact of AR/VR in other types of analysis and data visualization. Despite this, sectors with numerous knowledge workers may want to experiment with AR/VR, but with tightly scoped use cases until the technology improves. The next few years will likely see advancements that can enable sophisticated data visualizations that will amplify current analytical techniques.

Making AR/VR a reality

AR/VR is rapidly evolving from a curiosity, to a subject of experiments, to an enterprise tool that can offer broad benefits. Ongoing improvements in performance and cost will inevitably broaden the applications of this technology. The time is right for senior executives, including enterprise strategists, operations leaders, product owners, and marketing heads, to map out how they might put this technology to use.

AUTHORS

Ryan Kaiser is a manager in Deloitte LLP's US Innovation group, where his efforts focus on the intersection of innovation, strategy, and technology. He frequently evaluates emerging technologies and business trends to support strategic initiatives for Deloitte's leaders and clients.

David Schatsky is a managing director at Deloitte LLP. He tracks and analyzes emerging technology and business trends, including the growing impact of cognitive technologies, for the firm's leaders and its clients.

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