AUGMENTED REALITY

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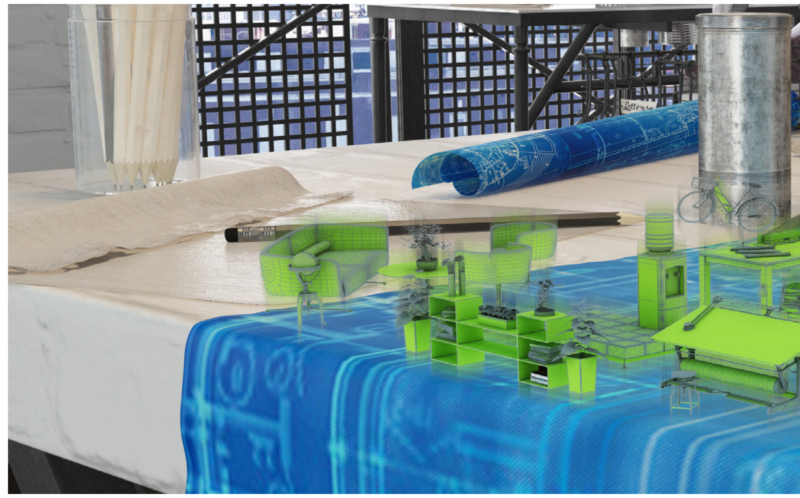
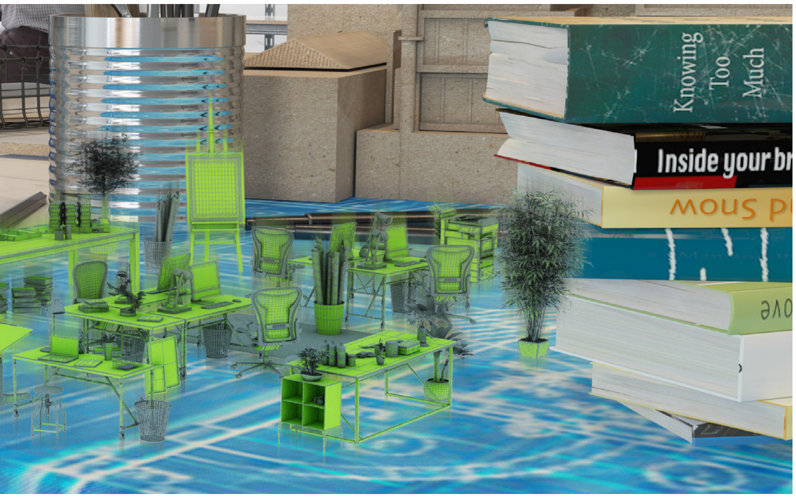
In This Issue





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Welcome from the Editor

Engineers and scientists have long been fascinated with the notion of seeing what's not visible to the naked eye—a capability that's thought of as a power only afforded to superheroes. Superman's "x-ray vision" probably comes to mind as the superpower to see through walls, surfaces, and other visual barriers to view what's obscured. X-ray vision was one of Superman's first published superpowers, which was illustrated in the April 1939 issue of *Action Comics*®.

These days, *augmented reality* is helping us mere mortals see with similar super-vision by giving users a view of the physical environment and overlaying it with computer-generated sensory input such as graphics, video, sound, or GPS data. Whereas a number of technologies allow us to get a picture of what's obscured (such as x-rays) or get diagnostic reports (such as sensor test output), augmented reality affords us better vision: The ability to see what's visible and what's not visible.

Augmented reality applications have the unique potential to provide the right information at the right time in the right place, like Superman swooping in from out of nowhere at the last split-second—seeing and hearing and sensing what others can't—and saving the day. The potential power isn't just in having that additional data, but in how it enhances our capabilities to do more than we otherwise could.

As we engineer solutions, we must consider the value of making what's not visible easily accessible and of affording users enhanced vision into their everyday environments. While we might not be able to make superheroes out of ordinary people, we can empower them with technological solutions like augmented reality. In doing so, we might become superheroes ourselves. ●

Deborah S. Ray

Editor, Mouser Electronics

Engineering New Realities in Augmented Reality

By Grant Imahara

Most people are already familiar with Virtual Reality (VR), especially computer gamers and tech enthusiasts. There have been numerous demos of VR environments that allow you to tour the world of *Game of Thrones*®, or perform missions on Mars, battle zombies, or even pilot the Starship Enterprise. It's so pervasive in mainstream media that even the cable comedy show *Silicon Valley* includes a VR start-up as part of its storyline. And while everyone knows about VR, far fewer are acquainted with AR (Augmented Reality). Or at least, they're not familiar with the applications of AR beyond playing *Pokémon Go* on their smartphones. To complicate matters, the technology lines between VR and AR are often blurred.

Whereas VR is a completely simulated digital environment, AR is reality that's enhanced with a real-time digital information overlay. Virtual elements like sound, video, graphics, GPS data, and more are introduced using viewers built into helmets, glasses, smart tablets, or even smartphones. Just think, back when we were in engineering school reading our textbooks, wouldn't it have been cool to have a photo of a motor animate by placing our smartphone over it or have other 3-D working diagrams we could study?

And that's only the beginning. In medical applications, AR can project information directly on a patient's body for more insight. For example, VeinViewer allows clinicians and hospital staff to see vasculature deeper and more accurately by projecting a real-time image of infrared vein scans directly onto the patient's skin. On the factory floor, AR has the potential to assist front-line workers with clear and timely processes at a mere glance. It can help workforces identify and understand 3-D objects quickly, allowing the system to help laborers pick correct parts, products, and more. Hopefully, you're starting to get a feeling for the amazing future that AR technology promises.

In our continual quest of Empowering Innovation Together, we visit a company in Los Angeles called DAQRI that's attempting to solve real-world problems using this emerging technology. Now, I know some of you are probably wondering why we're embracing AR when even the mighty Google couldn't make Google Glass a lasting reality. The answer is simple: Because future technology breakthroughs and innovations are often born from past failures. What's more, one innovation often inspires engineers to create the next big breakthrough.

In fact, AR is making its way into a number of industries. Not to mention the advancing developments in consumer smart devices (better cameras and more computing power) now opens a lot of exciting new opportunities in mainstream consumer applications.

So, what is DAQRI doing with AR and what role will it have in shaping smarter cities? Their engineers have created a smart helmet with a powerful computer vision package that delivers best-in-class AR even in the toughest industrial environments. The helmet is packed with multiple sensors and types of cameras, and features long battery life and attention to ergonomic design so it can be worn for extended periods of time in the field. When I put the helmet on, it was like I had Superman's x-ray vision. Instructions floated in front of me, levitating somewhere between me and the object I was supposed to fix. An alert suddenly appeared and I followed the instructions like a GPS in front of my face, systematically, until it was fixed. Built-in thermal sensors allowed me to quickly find a panel that was overheating. When you picture a future where every city worker has this incredible technology at their immediate disposal, you can start to see how much more productive they could be and the hours it could save.

What does the future hold for AR? Is it little more than a gimmick like many thought with Google Glass or *Pokémon Go*, or will it change the way we see things and enhance our experiences? Be sure to watch our next Shaping Smarter Cities episode for a glimpse at the new realities forming right before our eyes. ●

Augmented Reality

Beyond Gaming to Real-World Solutions

By Peter Brown for Mouser Electronics

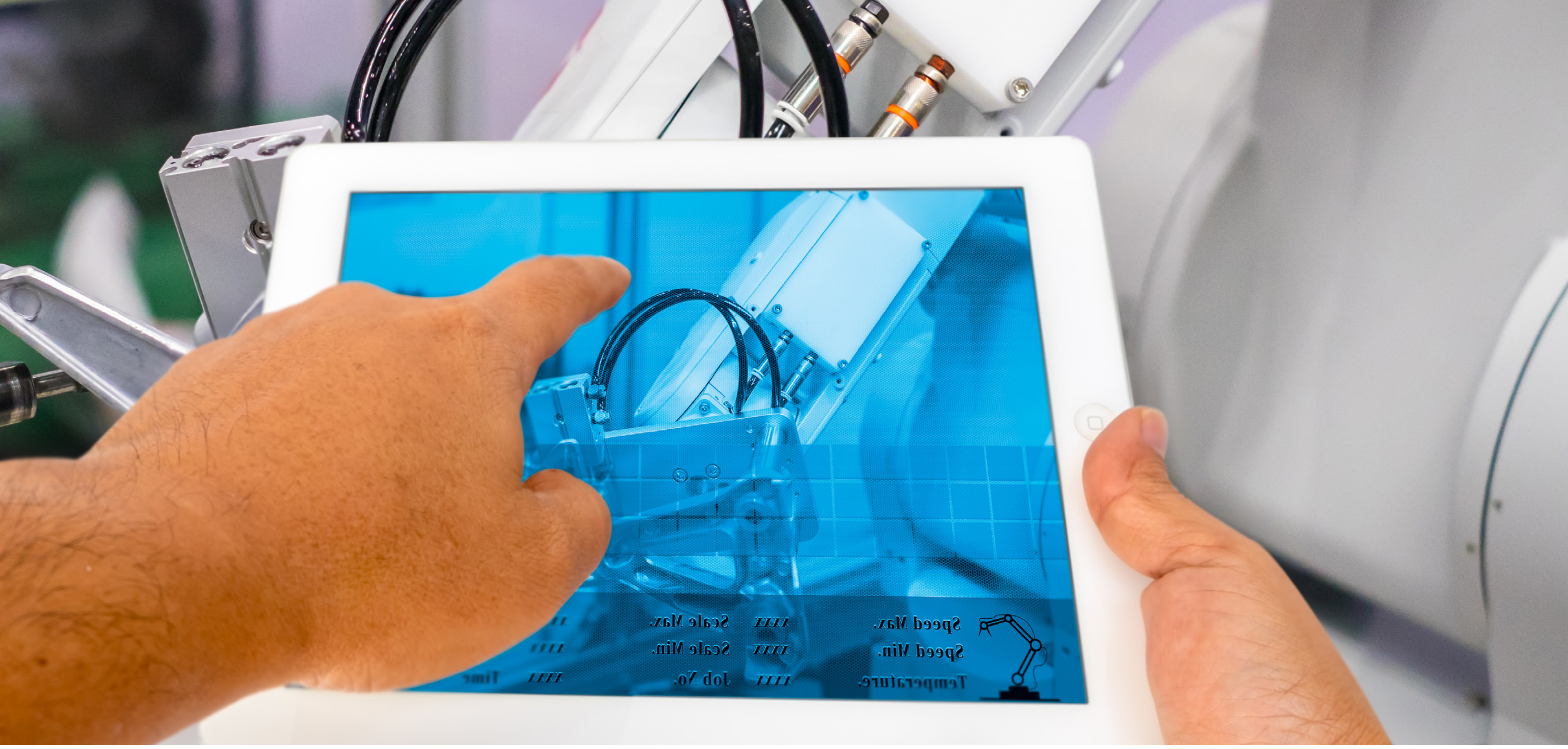
Ask a stranger off the street what Virtual Reality (VR) is or how it works, and most people will have some inclination of what the technology entails, maybe even equating it to the ultimate VR implementation in the Holodeck from the television series *Star Trek: The Next Generation*®. However, ask that same person about Augmented Reality (AR), and the answers are less likely to be easily gained. Maybe someone will talk about the gaming aspect of the technology or its earliest incarnation in the failed Google Glass.

While the idea of AR has been around for a while, it didn't garner worldwide attention until the launch of *Pokémon Go*, the video game that combined smartphone imagery with a real world scavenger hunt to let gamers experience both real and virtual worlds. But what, exactly, is AR? And as a burgeoning technology, does it offer potential beyond gaming and entertainment as a solution to real-world problems? This article explores a variety of AR pilot programs and applications across multiple industries, including healthcare, law enforcement, education, logistics, construction, and more. As you'll see, AR is being transformed into a platform for use across multiple industries for practical uses—a technology that could go from simple pilot projects today to something people use every day as part of their daily lives.

What is Augmented Reality?

Augmented reality, or sometimes called *mixed reality*, is a technology that merges real world objects or the environment with virtual elements generated by sensory input devices for sound, video, graphics or GPS data. Unlike virtual reality, which completely replaces the real world with a virtual one, AR operates in real-time and is interactive with objects found in the environment providing an overlaid virtual display over the real one.

While popularized by gaming, AR technology has shown a prowess for bringing an interactive digital world into a person's perceived real world, where the digital aspect can reveal more information about a real-world object than is seen in reality. Imagine doctors being able to see inside a patient during an examination, rather than by viewing scans and x-rays. Imagine kids learning about molecules by being able to interact with them. Imagine being able to see what maintenance and repairs are needed on a piece of machinery just by looking at it.



The Next-Generation of Healthcare

With the high costs of healthcare not going away any time soon combined with an aging population in many regions, medical technology is looking to help not just cut the costs for hospitals, providers and insurance carriers but also provide better, less invasive techniques toward treatment. Augmented reality has found a home here with the technology being used as a preventive measure to provide healthcare professionals to receive data in a non-traditional way.

Healthcare giant Cigna just this year launched a program called BioBall that uses Microsoft HoloLens technology in an interactive game to test for blood pressure and body mass index. Patients hold a light, medium-sized ball in their hands in a one-minute race to capture all the images that flash on a screen in front of them. The BioBall senses a player's pulse and uses responsive light to connect the game with the player's heartbeat. Once the game is over, patients receive their health numbers privately in their headsets with suggestions offered to be sent to an associated email address. Cigna says the technology is a way to encourage people to take control of their health by knowing their health numbers, so treatment then can be garnered accordingly.

Over at the University of Maryland's Augmentarium virtual and augmented reality laboratory, the school is using AR in healthcare to improve how ultrasound is done (**Figure 1**). Using a Microsoft HoloLens and special software, physicians wearing an AR device can look at both a patient and ultrasound imaging directly in front of them instead having to look at a bulky screen off to the side, says Barbara Brawn-Cinani, Associate Director for University of Maryland's Center for Health-Related Informatics and Bioimaging (CHIB).

And ultrasound is only the beginning for AR. "We're only scratching the surface on surgical applications, and we're planning for similar interfaces for other imaging modalities, and also field testing to determine how well this kind of tool actually works," Brawn-Cinani says.

Other companies are working on new platforms that use AR for more complex procedures. Scopis, for example, is developing a tool to give surgeons enhanced vision while performing spinal surgery.

__Figure 1:__ A doctor uses HoloLens and augmented reality software to see ultrasound while directly in front of a patient. (Source: University of Maryland)

Putting Old Knowledge in New Formats

Meanwhile, AR is opening up new ways to teach kids a variety of subjects they might or might not be interested in learning or, in some cases, help those that have trouble in class catch up with the rest of the students. The University of Helsinki in Finland's AR program helps struggling kids learn science by enabling them to virtually interact with the molecule movement in gases, gravity, sound waves, and airplane wind physics. The university found that AR was enough of a boost for these low-performing children to bridge the gap with other students who were also learning science. It was also shown to help improve the quality of learning in high-performing students.

AR also creates new types of learning by transporting "old knowledge" into a new format. For example, the University of Helsinki says AR for learning became much more appealing because kids had already dabbled with the technology before with *Pokémon Go*. Similarly, using new technology to teach about the old world is also the idea behind Shifu's Orboot interactive STEM device (**Figure 2**). Orboot is an augmented reality educational globe that works with a tablet or smartphone for children to learn about history, animals, monuments, language and arts, weather and culture by interacting with 3-D content.

The information is provided through AR-generated 3-D models, voiceovers, and music for a more immersive experience to learning. The goal is to promote active learning and memory retention that would not be possible with just video content, Shifu says.

The New Boardroom

Projection-based augmented reality is emerging as a new way to cast virtual elements in the real world without the use of bulky headgear or glasses. That's why this type of AR is becoming a popular alternative for use in the home or office. Start-ups Lampix and Lightform are working on projection-based augmented reality for use in the boardroom, retail displays, hospitality, digital signage and more.

Lightform's device can attach to any projector, similar to a Go Pro, and can instantly generate augmented reality elements (**Figure 3**). This may be useful for doing work with multiple groups in an office or creating elements for artists in a studio or presenting new products for display in a retail signage application.

"We think the influx point for type of technology is five minutes," says Phil Reyneri, Design Director at Lightform. "If you are going to be in an extended period time, it makes sense to strap on an AR or VR headset. But if you are doing something that is more of a quick

Figure 2: *The Orboot system can be used to teach weather patterns in a particular part of the country, among other topics. (Source: Shifu)*

Figure 3: *This device connects to any projector to create augmented reality elements for retail, home, or office use. (Source: Lightform)*

type experience—such as walking through a store or mall—it is more of a frictionless experience. Also you can have many people simultaneously experience augmented reality because there is not expensive headset that an individual has to wear."

Lampix has developed a lamp that uses a projection module, vision module, and a computer to project augmented reality on a surface that becomes active. Because no headsets or glasses are needed, the lamp-type device could be placed in a boardroom, where collaborative efforts could be worked on both on and off site, says Lampix CTO and co-founder Mihai Dumitrescu.

"AR has to be seamlessly integrated into everyday life in order to make sense. When it gets to that point, applications are endless, and it really has the potential to improve and make a lot of our activities more fluent," Dumitrescu says. "The focus should not be on the technology itself but much more on the experience. Lampix has a great potential to accomplish this because it is technology that vanishes into the background. You do not need to see the device, it is just the experience that emerges, that is meaningful and useful."

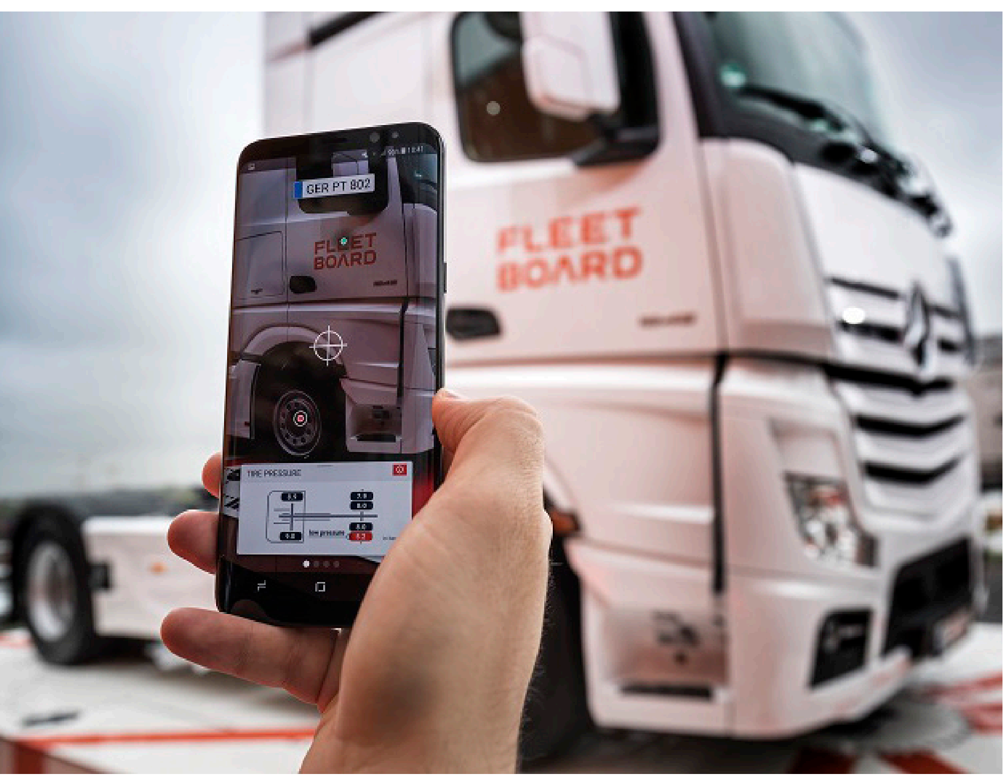
From Finding Tiny DNA to the Vastness of Space

Meaningful and useful is what companies and think-tanks are working on worldwide. In fact, augmented reality is finding its way into just about every industry and market, at least in a pilot phase. In Germany, for example, FleetBoard is in the development phase of an app that tracks logistics for truck drivers to help with the long series of pre-departure checks before setting off. The FleetBoard Vehicle Lens app (**Figure 4**) uses a smartphone and software to provide live image recognition to identify the truck's number plate. Then the relevant information is superimposed in augmented reality, speeding up the pre-departure process.

FleetBoard is also working with Microsoft's HoloLens to create a new way to manage truck fleets. On an abstract road map, the surface is brought to life with augmented reality allowing fleet manager's to monitor vehicles live in a 3-D landscape to prevent accidents and delays, and to warn drivers of possible problems on the road ahead.

Last winter, Delft University of Technology in the Netherlands started working with first responders to use AR as a tool in crime scene investigation. The handheld AR system allows on-scene investigators to work with remote forensic teams to minimize the potential for contamination. AR is also seen as a way to have multiple sets of eyes on a crime scene that normally wouldn't have more than just the first responder there. This could be extremely helpful in finding traces of DNA, preserving evidence, and getting medical help from an outside source.

Figure 4: *Fleetboard Vehicle Lens app is a pilot project that tracks a truck's number plate and superimposes the information in augmented reality. (Source: FleetBoard)*



Sandia National Laboratories is working with augmented reality as a tool to improve security training for users that are protecting vulnerable areas such as nuclear weapons or nuclear materials. The physical security training helps guide users through real-world examples such as theft or sabotage in order to be better prepared when an event takes place. The training can be done remotely and cheaply using stand-alone AR headsets.

In Finland, the VTT Technical Research Center recently developed an augmented reality tool for the European Space Agency (ESA) for astronauts to perform real-time equipment monitoring in space. Because these tasks must be carried out without errors and at the right time, AR prepares astronauts with in-depth practice by coordinating the activities with experts in a mixed-reality situation. The tool makes the invisible visible by enabling the visualization of telemetry data from equipment and other systems on board the space station such as diagnostics and the latest maintenance data, life cycle, radiation, pressure, or temperature—both in space and on the ground and displayed on AR glasses.

In the U.S., DAQRI International uses computer vision for industrial AR to enable data visualization while working on machinery or in a warehouse. The glasses and headsets from DAQRI display in the field of view project data, tasks that need to be completed, and potential problems with machinery or even where an object needs to be placed or repaired. Using AR can improve safety and efficiency in an industrial job space while making repairs, maintenance and inventory management easier.

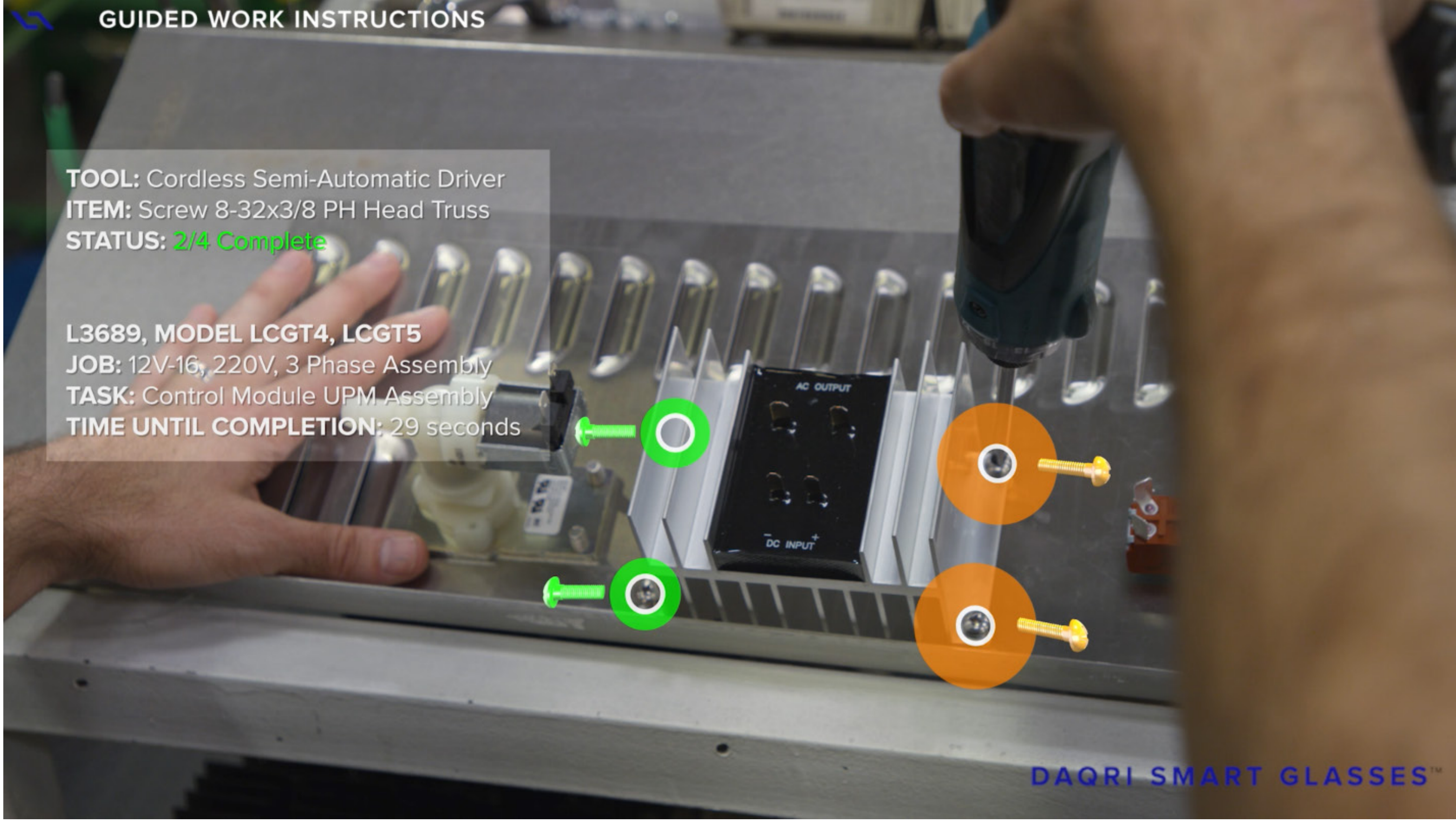


***Figure 5:** Workers view the task that needs to be completed as a visual element in DAQRI's AR headset or glasses. (Source: DAQRI)*

Conclusion

Augmented reality merges real world objects or the environment with virtual elements generated by sensory input devices for sound, video, graphics or GPS data. AR operates in real-time and is interactive with objects found in the environment providing an overlaid virtual display over the real one. Although *Pokémon Go* continues to be popular with gamers, companies around the world are already demonstrating the potential for using AR to solve real-world problems and needs. Industries such as law enforcement, education, logistics, construction, and others are prototyping and using AR technologies and reporting promising outcomes, such as training, monitoring, and collaboration that's more effective and efficient. As for the future of AR? With continued development of AR technologies, the reality of widely-used practical applications is on the horizon.

AR Hardware Ready to Serve Industrial Use Cases

By Majeed Ahmad for Mouser Electronics

Time magazine and *ABI Research* have called augmented reality (AR) the future of technology. Why? Because it marks the nexus where the digital and physical worlds collide, and it creates game-changing opportunities for industries ranging from manufacturing to energy to healthcare. The notion of AR has been around for many years, fascinating hobbyists and technology enthusiasts with its ability to overlay text and image on real-world objects. However, in 2016, smartphone game *Pokémon Go* thrust AR into the mainstream while showing the world how AR devices could extend themselves into a tool for the futuristic industrial worker.

Designing AR devices poses several hardware challenges. This article shows how AR can transform industrial environments like construction sites and factory floors and explores ways to overcome challenges in designing viable AR products.

The 21st Century Industrial Worker

The idea of empowering industrial workers in the workplace as well as in the field by superimposing digital information onto physical objects is very powerful and is poised to revolutionize many industries. For example, AR has shown the potential to reinvigorate the manufacturing sector by connecting workers with equipment and allowing them to interact with sensor data. That enables factory workers to automate guidelines or standards and see specific instructional content in real-time.

A case in point is a factory worker who follows step-by step instructions on how to assemble a product or an industrial designer who uses AR to show side-by-side comparisons of new and old product designs while bypassing the need for creating expensive prototypes merely for display purposes. Other examples include field personnel drawing help from experts at remote locations via markings, messages, and diagrams made available on a glass screen while they are fixing equipment. A technician using AR wear can manage pump station operations without going back and forth to a computer console. The AR technology even allows new employees and DIY-ers to identify problems and perform repairs by following step-by-step instructions using AR overlays. Hyundai

launched an AR manual for car owners in 2015. This app, available on smartphones and tablets, allows car owners to scan various parts of their vehicle and perform repairs using 3-D overlay images and how-to videos. These are only a few ways that AR can empower a mobile workforce while taking pressure off experts at central locations.

Designing the Human-Machine Interface

The human-machine interface in AR overlays schematics and audio onto real objects in order to facilitate tasks such as motion tracking, pattern recognition, and data visualization. AR hardware—encompassing cameras, sensors, displays, and connectors—is quickly refining itself and the human-machine interface it employs in designs serving industrial applications.

Designing AR interfaces poses unique challenges. To begin, APIs and the apps ecosystem are still evolving, and the limited field of view in helmets, headsets, and displays pose unique challenges in hardware selection:

Displays demand thinner and lighter components to meet industrial design requirements (**Figure 1**).

- Power delivery must be efficient to prevent data overloads and device breakdown.
- Components like cameras, sensors, and displays, must accommodate ultra-high speed streaming of graphics and video with near-zero latency.
- Connectors must be compact, light, fast, and reliable.

Figure 1: *AR devices like smart glasses demand thinner and lighter components to meet industrial design requirements. (Source: DAQRI)*

Unique Requirements for Connectors in AR Devices

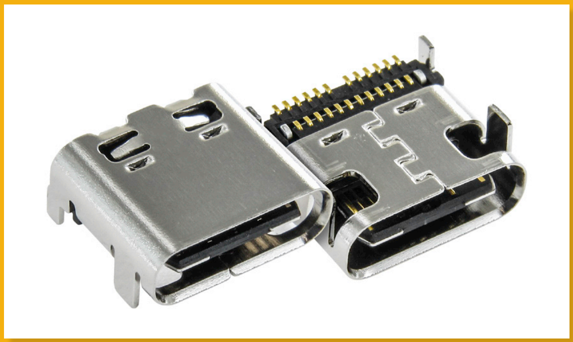
Connectors are especially important in AR hardware designs. In general, they need to be compact, light, and fast; AR designs demand miniaturized connectors to replace bulky interconnect solutions with limited pin counts. And these connectors should be reliable enough to ensure signal integrity while serving AR applications that employ high-speed data links.

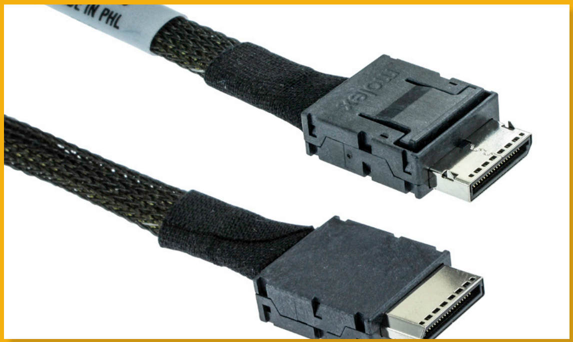
Further, connectors in AR designs are required to meet the rising data transfer needs along with increased port density, and they should be able to provide multiprotocol support in order to facilitate a multitude of technologies. The [Nano-Pitch I/O interconnect system] from Molex boasts enhanced data speed and signal integrity in increasingly compact form factors. Moreover, it offers a flexible pinout that is optimized for high-speed applications. It also maximizes the number of high-speed lanes within the available cable lengths. These connectors measure 5mm × 23mm × 9mm and feature a 12mm mated connector-to-cable assembly height for right-angle cable exit (**Figure 2**). That makes them highly suitable for AR devices such as headsets and glasses.

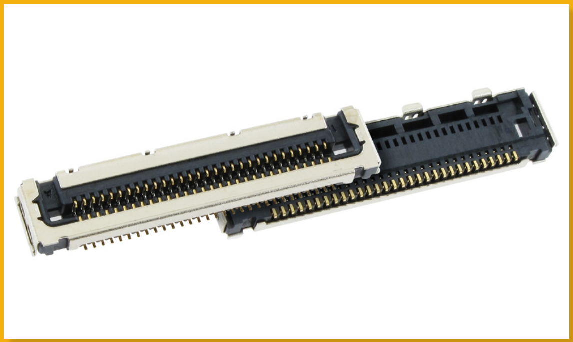
The highly compact AR devices also mandate connectors provide optimal routing for high-speed trace connections in order to shrink the PCB real estate. Molex›s Nano-Pitch I/O connectors ensure design flexibility with vertical and bulkhead PCB configurations.

Power supply connectors are robust enough to transport power for video subsystems like the stereo camera. Power connectors in small form factors typically face the dilemma of choosing between headers that expose terminals to external damages and fully isolated headers that take up too much space.

[Nano-Fit power connectors] from Molex address this design challenge with a fully isolated terminal design that keeps the pitch package to a mere 2.5mm. Moreover, to simplify assembly on a PCB with multiple headers of the same circuit size, these power connectors offer keying options that facilitate proper mating and terminal position assurance (TPA) to eliminate the risk of terminal backout.







Conclusion

ABI Research expects AR for enterprise applications to hit an inflection point in 2018 because it has the potential to create game-changing new opportunities for industries ranging from manufacturing to energy to healthcare. AR designers are quickly overcoming the hardware challenges, and the technology as a whole is gaining traction a lot faster than many industry watchers may have thought possible. AR device design requires a number of hardware considerations, especially for connectors. *Pokémon Go* showed the world how AR could engage people. Now it's our turn to create AR devices for uses in other industries and bring the potential of AR to the forefront. ●

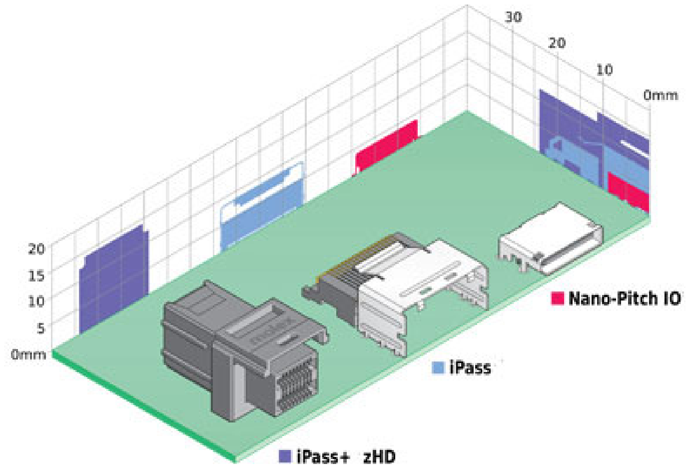


Figure 2: *Connector miniaturization is essential for cramming more circuitry into ultra-compact AR designs. (Source: Molex)*

Augmented Reality Improves Medical Education and Health Care

Modern chips power AR tools that help healthcare staff safely practice new skills

By Steven Keeping for Mouser Electronics

While the consumer might be more excited about Virtual Reality (VR), the related technology of Augmented Reality (AR) is proving more interesting to the commercial and industrial sectors. Unlike VR, AR doesn't replace the real world with a virtual one; rather it combines the two, making it far more suited to business applications.

A new generation of powerful and compact cameras, FPGAs, microprocessors, graphic chips, wireless transceivers, and voltage regulators power AR products that enable commercial operations to augment employees' skills, improving productivity and safety.

Nowhere is AR more prevalent than the medical sector. AR tools such as a device that projects a remote skilled physician's hands onto a complex medical procedure to guide a less experienced surgeon, or another to aid location of a patient's veins, enable healthcare staff to quickly gain skills that would otherwise take much longer to acquire. Such tools also enable inexperienced staff to safely perform procedures that would otherwise be considered too risky. In doing so, the tools help cut waiting times or bring procedures to areas of the globe that previously lacked them.

This article describes how AR is improving health care by moving from the R&D lab to the treatment room. The article goes on to explain how this move is being driven by hardware that has become powerful enough to cope with high volumes of data and high-definition 3-D image rendering without being prohibitively expensive, clunky, or consuming too much power.

Figure 1: *Google Glass has been relaunched and is finding favor for medical education AR applications. (Source: Wikipedia. By Mikepanhu - Own work, CC BY-SA 3.0.)*

What is AR?

The key difference between VR and AR is that the former attempts to create an alternative reality to that which the user inhabits while AR enables a user to retain complete awareness of their situation while enhancing sensory perception through provision of contextual information and feedback.

VR's "immersive" experience—saturating the user's visual and audio senses with an artificial environment—makes it well suited to entertainment and leisure activities such as gaming. In contrast, by combining the real world with useful elements of a virtual one, AR makes the technology more practical. This usefulness suits work-related applications because the computer-generated information is presented in a way that carefully complements the user's perception of environmental cues to either accelerate learning of new skills or improve productivity when performing familiar tasks.

Benefits of AR

The key advantages of AR that make it a good match for commercial and industrial applications include:

- Hands-free operation, allowing tasks to be safely performed while receiving instructions.
- Expert guidance and instruction either from pre-recorded sources or from a remote trainer, improving productivity and eliminating mistakes.
- Interactive and contextual directions, instructions, and warnings.
- Compact, lightweight, and comfortable headsets when compared with bulky, wrap-around VR models.
- Real-time high-definition video recording of tasks for both local and remote colleagues.
- Access to Internet and Cloud resources for information and analysis.
- Rapid communication over VoIP or video services.
- Visualization in 2- or 3-D of concepts before physical prototypes are constructed.

Medical Applications of AR?

The advantages and practicality of AR make it particularly suited for the medical sector. Physicians, nurses, and other healthcare staff require intensive training to ensure the best patient health outcomes. Such training is expensive and time-consuming; a key challenge for a sector that is continually under budgetary pressure. AR enhances and accelerates this training, helping to improve the quality of qualified individuals while keeping a lid on costs.

Second, AR can help "de-skill" many diagnoses and procedures so they can be safely performed by lower-level staff, freeing up higher-level staff for more pressing tasks and again saving costs. Third, AR can assist high-level yet inexperienced staff to safely perform procedures that previously they would be unable to attempt. Finally, AR helps to migrate medical skills from the developed to the developing world, improving the healthcare of less wealthy populations.

Some pioneering companies have already introduced AR products into medical segments including these:

Training

U.K.-based Medical Realities Founder, Dr. Shafi Ahmed, has used Google Glass (a relaunched version of an earlier consumer AR headset now targeted at the enterprise sector (**Figure 1**) to perform live operations which have been broadcast to 14,000 students in 32 countries. Ahmed is also a council member of the U.K.'s Royal College of Surgeons and believes most healthcare professionals will soon be taught with AR. Real cadavers will be replaced with AR anatomy sessions, and teaching and learning will be done with headsets such as Microsoft's HoloLens (another AR headset targeted at the enterprise market).

Another medical student training aid has been developed for HoloLens by Case Western Reserve University in the U.S. When wearing HoloLens headsets, students can see inside a human body to observe the organs and circulatory/respiratory systems. The "body" can be rotated to reveal, for example, the pancreas, which is obscured by the stomach when a person is observed from the front. The application can also do things like add muscles to a skeleton, or project the heart out of the chest to enable closer examination.

A third application comes from ARnatomy. This app is not yet ready for an AR headset (it currently runs on a tablet computer), but it does nicely demonstrate the principle of providing contextual information for objects viewed by the user. In this case, the objects are bones and muscles examined by medical students. When placed in front of the tablet computer's camera, the bones and muscles are annotated to reveal the names of their constituent parts.

Surgical Procedures

In the U.S., a University of Alabama at Birmingham surgical team recently used AR technology from VIPAAR (Virtual Interactive Presence in Augmented Reality) in conjunction with Google Glass. The team performed shoulder replacement surgery while a remote physician observed and interacted.

The Google Glass camera transmitted the image and allowed the remote physician to see exactly what the surgeon saw while being able to introduce his hands or instruments into the "virtual surgical field." At the same time, the surgeon observed the remote physician's hands and instruments in his head-up display (HUD), along with his own field of view, as a "merged-reality" environment. The two doctors were also able to

Figure 2: *AccuVein® is improving venipuncture, easing pain and distress among young, old and obese patients. (Source: AccuVein)*

discuss the case in an interactive fashion as if they were standing next to each.

Blood Extraction

AccuVein® is a portable AR device that projects an accurate image of the location of peripheral veins onto a patient's skin. The aim of the product is to improve venipuncture, the most commonly performed invasive medical procedure. Drawing blood is a routine task, but is made more challenging if the healthcare professional has difficulty locating a vein—something that's common in young, old, or obese patients. Forty percent of the time, the vein is missed the first time when dealing with these groups of patients, and repeated pricking causes pain and distress. AccuVein (**Figure 2**) is in use in hospitals across the U.S., and the company estimates it increases the probability of finding a vein first time by 3.5 times.

Assistance for Partially Sighted

Other AR prototypes under development include glasses that enhance facial features to make it easier for partially sighted patients to recognize people as well as products that simulate eye problems such as cataracts to enable patients to more accurately describe the nature and severity of their symptoms.

Emergency Assistance

Many consumers' first experience with AR came in the form of the *Pokémon Go* app, which used a smartphone to superimpose Pokémon characters on the real world when viewed through the handheld device's camera. A more pragmatic application of similar technology comes in the form of a smartphone AR app that indicates location of defibrillators, again superimposed on the image of the real world captured by the device's camera, for use in cases of cardiac arrest in public places.

Designing AR Medical Products

AR remained an "emerging" technology for years because processing power, graphics rendering, wireless connectivity, and batteries had yet to meet its demands. Today, the technology has matured to the point that early product designs are approaching full commercialization.

Because some 66 percent of the brain is devoted to processing vision (according to several studies), glasses incorporating HUDs are the most practical form factor for an AR device. HoloLens and Google Glass headsets are pioneering examples of such designs. These products are still relatively heavy, clunky, and require large rechargeable batteries, but they demonstrate that AR headsets are now practical because of the impressive capabilities of today's electronics.

Ongoing silicon and battery development will ensure greater miniaturization and efficiency for future products. The second generation of AR headsets will probably look and feel much like ordinary spectacles with lenses featuring built-in waveguides projecting the output of compact projectors on each arm across the whole surface of each lens. The projected information will not only comprise text, but high-definition images and video for each eye across a 120° field of vision (mirroring full VR) to augment what the user is experiencing in the real world.

Hardware Building Blocks of AR

AR headsets use motion sensors to determine head movements and cameras to capture high-quality 3-D images allowing the device to interpret the scene. Headsets typically incorporate FPGAs to buffer, digitize, and encode that data captured by the cameras. The data is then passed to the microprocessor, which in turn determines which images should be rendered on the lenses to assist the wearer.

With some exceptions (for example, HoloLens, which is a self-sufficient computing device), today's headsets work in tandem with a smartphone to complement the onboard computations requirements, simplify Internet connectivity, and reduce power consumption. Reliance on the smartphone will continue for many second-generation AR headsets.

Smartphone connectivity demands a reliable, low-latency, high-bandwidth wireless connection interoperable with the smartphone such as Wi-Fi or Bluetooth 3.0+HS (High Speed). As silicon advances, the headsets will operate as standalone devices directly connected to the Internet, eliminating reliance on the smartphone.

In a working environment, AR medical products will require at least eight hours of battery lifetime, so they need to be designed with low power consumption in mind. The most likely power source is lithium-ion (Li-ion) cells like those used to power cellphones.

Examples of commercially-available devices and chips for AR headset applications include the following:

Cameras

Intel's® RealSense™ Camera is designed for AR projects. Two models are available: the R200 and the SR300. The units are offered as compact (110mm x 12.6mm x 4.1mm thickness) sub-assemblies to make them easier to integrate into prototype headsets. The

Figure 3: *Intel's SR300 camera is offered as a compact subassembly to ease incorporation into prototype AR headsets. (Source: Mouser)*

RealSense cameras implement a short-range, coded light 3-D imaging system with depth capture from 0.2 to 1.5m, 60 frames per second (FPS) depth at 640 x 480, and up to 30 FPS color at 1920 x 1080 (**Figure 3**). The RealSense cameras are accompanied by a software development kit (SDK), which allows developers to integrate hand/finger tracking, facial analysis, scene perception, and depth-enabled photography into their AR applications.

Buffering and Encoding

FPGAs such as Intel Stratix V High Bandwidth Series provide designers with the flexibility to develop custom circuitry to buffer and perform the digital processing demanded before the data is passed to the system microprocessor.

The Intel Stratix V FPGAs incorporate a rich set of high-performance building blocks, including a redesigned adaptive logic module (ALM), 20 Kbit (M20K) embedded memory blocks, variable precision DSP blocks, and fractional phase-locked loops (PLLs). The chip's high-speed digital signal processor (DSP) blocks are for common high-speed data manipulation tasks such as multiply-accumulate functions and finite impulse response (FIR) filters. Common to Stratix® V devices is the new Embedded HardCopy Block, which is a customizable hard IP block used to harden IP instantiation of PCIe Gen3, Gen2, and Gen1.

Processing Power

In addition to high processing power, the microprocessor for an AR application needs to fit the typical compact form factor and power budget of solutions. Intel's latest microprocessor for mobile applications, the Intel m7-6Y75 microprocessor, is a good choice for this type of product. The chip benefits from the company's latest 14-nm wafer fabrication process and features two cores that run at 1.2GHz (which can be boosted to 3.1GHz when required). The chip features a 4MB cache to keep the data flowing during intensive computational periods. The maximum memory bandwidth is 29.8GBps.

A key benefit of the Intel chip for AR medical applications is the built-in high-definition graphics support; the chip incorporates a graphics processor that can render images in resolutions up to 4096 x 2304 pixels. The microprocessor also includes support for Intel's 3-D and Clear Video HD Technology.

Wireless Connectivity

High-bandwidth wireless connectivity enabled by technology such as Wi-Fi or Bluetooth 3.0+HS is essential for streamed visual and audio data, plus fast Internet access.

Power Management

To maximize battery capacity and supply the precise voltages required by the electronic components, a voltage regulator such as Intel's EN6362QI PowerSoC DC-DC step-down ("buck") converter is a good foundation for the power supply. The converter offers a competitive combination of power density and conversion efficiency, and integrates power switches, inductor, gate drive, controller, and compensation in an 8 x 8 package.

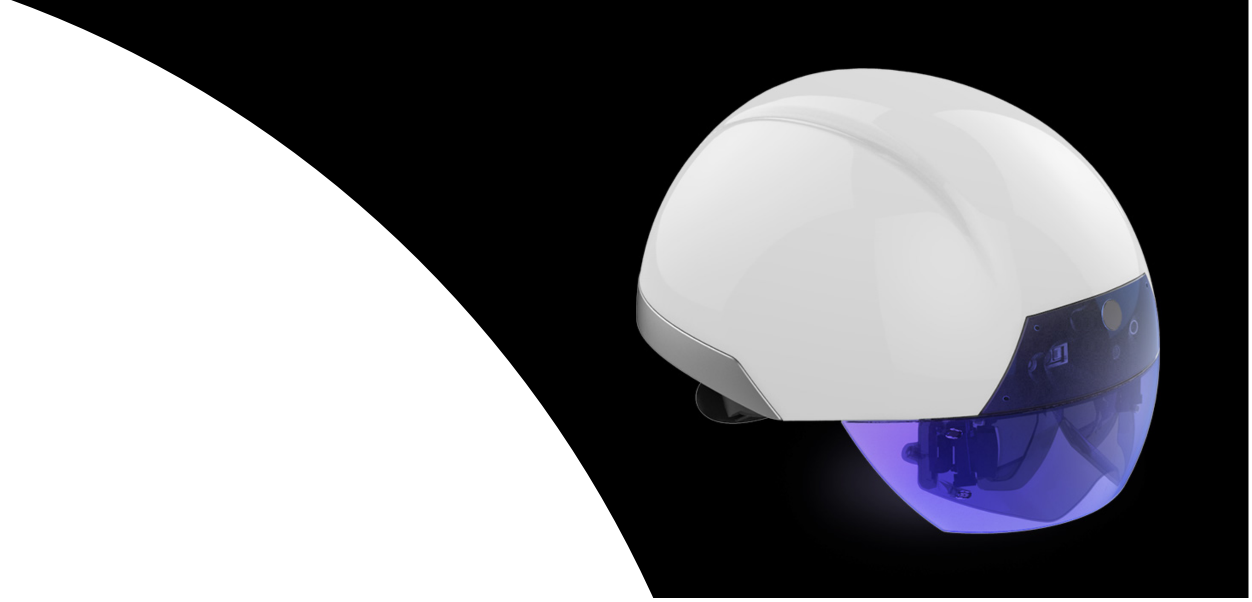
The Intel Stratix V FPGAs described here aid the quest for low power consumption through the ability to minimize power to those blocks not in use. Selectable core voltage also helps the designer manage the power budget. Similarly, the Intel m7-6Y75 microprocessor eases the load on the battery by consuming just 4.5W during typical operation (rising to a maximum of 7W during heavy-duty operation).

Conclusion

Unlike VR, AR doesn't replace the real world with a virtual one; rather it complements human perception of the environment with computer-generated graphics, making it far more suited to commercial and industrial applications. Nowhere is AR more prevalent than the medical sector where the technology melds the processing power of the latest electronics and software with the dexterity and empathy of healthcare professionals to provide a better outcome for patients.

While applications—based on pioneering AR products such *Google*® Glass and *Microsoft*® HoloLens® —for training and expert guidance in medical education and surgical procedures demonstrate the high-end of AR, devices such as AccuVein illustrate the scope for proprietary designs in virtually any segment of the medical sector. Technology that was once only available to fighter pilots can now be put in the hands of all healthcare professionals.

Modern electronics such as Intel's cameras, FPGAs, microprocessors, and power management devices meet the demands of healthcare AR applications while extending battery life, and together with the associated development tools, simplify design and speed time-to-market in this rapidly expanding sector. ●



Vision System and Photometric Sensors Bring Augmented Reality into View

By Paul Golata, Mouser Electronics

Humans have always tried to augment—expand—their physical abilities in one form or another. The human eye is a sophisticated system, allowing us to handle the daily complexities of life with ease and success. In 1610, Galileo looked into the heavens with a 30x telescope, forevermore augmenting human vision by allowing man to see details with clarity and precision yet before unobtainable.

The technology of Augmented Reality (AR) promises to do the same thing.

AR offers the hope of merging human eyesight and augmenting it by providing visual systems that superimposes additional information into the sight path, providing the user with abundantly more targeted information for the brain to process and respond intelligently. But augmenting human eyesight introduces new engineering challenges, which require targeted solutions such as vision systems and photometric sensors.

Vision System and Photometric Sensors

AR promises to offer new ways to envision three-dimensional (3-D) objects due to its ability to provide new composite ways of viewing objects. Overlays will be able to be manipulated to accentuate or deemphasize certain aspects based upon the users' preferences and their objective or tasks.

Figure 1: *The DAQRI Smart Helmet® combines sensors and processing in a small helmet. (Source: DAQRI)*

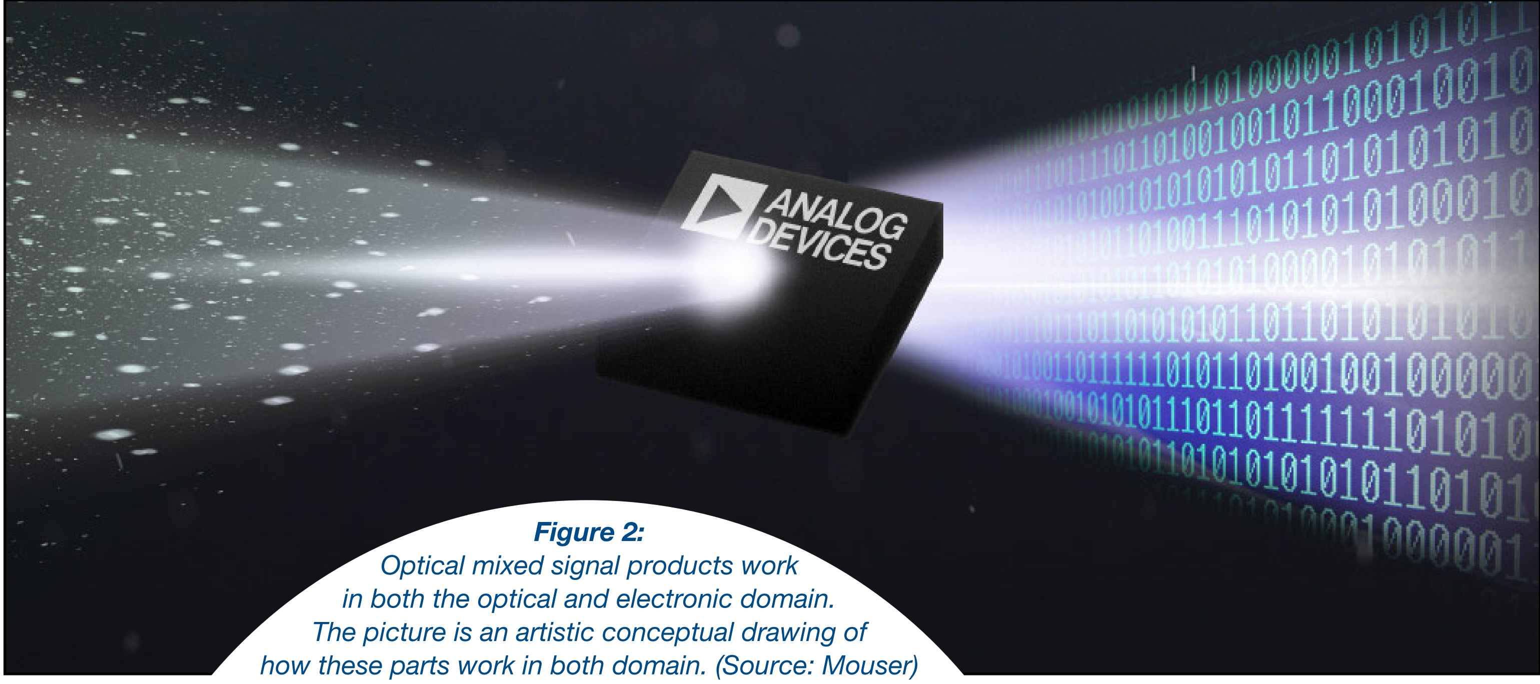


Figure 2:
Optical mixed signal products work in both the optical and electronic domain. The picture is an artistic conceptual drawing of how these parts work in both domain. (Source: Mouser)

One of the primary technical challenges involved in providing a properly framed picture that hangs in the mind is related to matching objects and their superimposition through orientations directly related to an external coordinate system. The performance of various work tasks requires a synchronized coupling between what human vision pictures and what the computer re-visions by way of superimposed information.

This solution may be achieved through several options that solve both the physics-related and mechanical engineering need for six degrees of freedom (6DoF: Up/down, left/right, forward/back, yaw, pitch, and roll) in order to provide unrestrained freedom and mobility to operate. Added technical issues are present because any AR eyewear must be placed upon the human head and optimized for being low in mass, requiring that sophisticated electronic systems be integrated as much as possible, combining both sensors and processing in small physical packages (**Figure 1**).

Designing vision systems require extensive technical expertise in two separate and specific spheres of activity and knowledge:

- The optical domain, which is primarily concerned with analog signals
- The electrical domain, which is concerned with both analog and digital signals

Vision systems then require expertise in optical mixed-signal processing (analog and digital). It makes sense to consider selecting products from companies that have specialized experience in mixed signal technology, such as Analog Devices®, where their analog and mixed signal IC technology has been their business bedrock for over four decades (**Figure 2**).

An AR vision system design may start with something like the Intel® RealSense™ camera, which is ideal for long range 3-D sensing. Besides a camera, a host of other optical mixed signal devices may be used, including highly integrated analog front ends (AFE) and integrated optical modules (IOM).

What is it that these parts do in order to provide the vision necessary for AR systems to operate successfully? In essence, they provide optical analog sensing functions that can be manipulated electronically. For example, take the issue of ambient light and how it is perceived by the human eye. This is known as photometry. The human eye is a senor, but it does not sense light in a manner that provides information regarding the radiant energy's absolute power. Rather, the human eye is a logarithmic-based dynamic photonic sensor.

Analog Devices makes the ADUX1020 Photometric Sensor, which like a human eye, is capable of optical object location and triangulation. The configurable analog front ends offer flexibility in optimizing a given solution and is coupled with a clock-generation LED driver and digital logic.

The ADUX1020 can be used to perform gesture touchless interface control (5mm–150mm), proximity (200mm), and presence measurements for AR applications. It is able to determine an objects' X-Y-Z coordinates in 3-D by viewing it through a predefined field-of-view (FOV). It obtains information data from the object by sending and receiving an infrared (IR) pulse that reflects back from the object to the sensor. The data obtained from the reflection forms information that forms a two-dimensional angle (X-plane, Y-plane) that the electronics processes. A second internal sensor provide another angle to be measured, thereby yielding information in the Z-plane by way of triangulation. This device is immune to external lights to avoid corruption caused by external interference.

Another optical mixed signal product, the [ADPD105 Photometric AFE](), can be used for time-of-flight (ToF) applications. It is usable for applications including depth sensing through the stimulation of an LED and the measurement of its optical return signal. A user may point an object toward something and know instantly how far the thing is away from the user.

Conclusion

As engineers, we look forward to the coming reality of AR. The trend toward AR requires us to increase our technical vision so that we can conquer the obstacles along the way. The use of optical mixed signal devices augments designs by allowing the domain of electronics to be combined with optics. In particular, AR vision systems provide optical analog sensing functions that can be manipulated electronically; photometric systems enable optical object location and triangulation. Incorporate parts that give you the advantage to see the future and make it so that your reality is augmented. After all, seeing is believing. ●

Augmented Reality in Architecture: Building Bridges or Just Castles in the Air?

By Sylvie Barak for Mouser Electronics

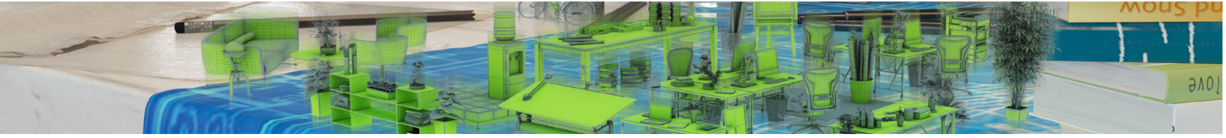
Augmented reality (AR) is still in its nascent stages, but a variety of industries and verticals are already beginning to use it in anticipation of its upcoming and full potential. One of these industries is the architecture and design space, which is eager for AR platforms and software to mature, so that the days of modeling and designing statically on a monitor and having to use one's imagination to "see" a space will be over.

We spoke to Alan Robles, the head of creative media at a large global architecture and design firm with 25 years' experience implementing new design practice, with a focus on how emerging technologies and the opportunities they create can enhance more natural interaction. "The idea that we could put our clients in the spaces we were designing before we had built anything was a really powerful engagement tool," he said, noting that his firm had begun dabbling with AR back in 2012, using QR codes, but that things had evolved rapidly, especially in the last couple of years.

"What AR is allowing us to do at this point is to really address existing spaces and add digital content to those existing places." Lacking a ready-made professional platform, the architects engaged with game engine companies to start cobbling together their own internal tools and platform. At first, said Robles, his team was using pass-through cameras mounted to goggles, a little bit like a GoPro camera, so the team could see the world around them through the goggles but then add content to the environment digitally. This ramshackle AR was a little unwieldly to use practically at first, but acted as a good proof-of-concept for how things could move forward.

In architecture and design, the beauty of AR is in its potential simplicity. Simply being able to overlay digital content on an image for a start. From there, things can scale up in complexity, to the level of allowing a person with an AR platform to see an environment a certain way, with various digital additions, and be able to interact with the environment, walk around it, move things, and so on.

Unlike virtual reality (VR) where one has to exist solely within a digitally contained space, AR offers a digital overlay that allows architects, clients, and designers to exist inside virtual geometry and occupy space there, while still seeing the real world. "Think about the level of translation you have to do with someone who is not



a practitioner [of architecture or design]. A lot of times we show clients a digital model or in some cases we build a physical model, and then ask them to 'duck down here, and look between these two buildings, and then try to imagine what the sight lines are going to be like.' Well, with AR, we are able to show them 1:1 real scale the things that we are proposing."

Robles gave the example of some work his firm has done in collaboration with a company that manufactures and sells high-end kitchens, where they were able to input the kitchen designs to the AR platform, let people virtually walk around the physical showroom space with the AR headset, and allow them to change dimensions of things, change tiling schemes and colors, and move appliances around.

"Clients loved it!" he enthused.

Robles said he saw the potential for AR in architecture immediately, even from the early days of using it to scan QR codes and bring up various digital models on a tablet, something that's now considered "old school." Recently, the firm used AR to help architects design a Los Angeles, CA football club stadium that's currently under construction. Robles said AR was instrumental throughout the development, from evaluating the structure, to evaluating design options, to creating materials, to communicating the end design product. The firm used developer-available AR platforms and again reached out to video game technology companies to help them in the realization of putting "very big models on small devices" and in making them available to display and share with stakeholders.

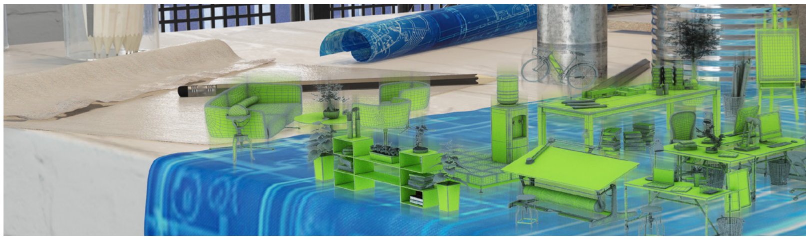
"Instead of looking at computer, phone, or tablet screens, there is a future where professionals will not require screens and, instead, information will just appear in their field of view when they need it to."

"Right now, the devices we can use in order to share and practically apply the technology are still in their early stages, so there's a lot of compromise around them," noted Robles. Indeed, many still need to be tethered—connected to a computer—because untethered devices are still somewhat limited in terms of compute or battery power, making them impractical. Limited compute power means the devices can't host large or very detailed models, which is something of a current hindrance. "Right now we use them strategically to communicate specific parts of a design story, but in the future, as these devices mature, we will really see things ramping considerably," said Robles.

Robles' company, like many other architectural firms dipping their toes into the AR space, is platform agnostic. "We don't subscribe to the piece of hardware that delivers it; we develop the content and game engines. Then for whatever device we need to use, we just output that content from the game engine to that device."

Currently, Robles claims, only around 25 percent of projects at his firm implement AR to its current potential, which is low, but a result of the infancy of the technology, specifically the immaturity of both the hardware platforms and software to support it. If one were to count the additional use of QR code-based AR or tablet/phone-based AR, then that percentage jumps closer to half, he said.

The ideal when it comes to AR



“I would want something untethered, with an onboard processor, with a really wide FOV as close to a natural FOV as possible, with great battery life, with the ability to connect to other devices and computers, and with even more computing power.”

and architecture, said Robles, would be to completely replace the computer monitor. “If you think about your desk at work, the thing that dictates how big it is and where it’s located is all about the hardware that you need to have on it. The monitors dictate how wide it is, and you›ve got a phone and a lamp and all these physical artifacts that dictate that desk. But if we remove all of these, because they exist in your vision, in a software database that’s delivered directly to your eyes, that really changes your ability to address work. It changes where you work, it changes how you can work, and it actually allows you to formulate how you would access your most heightened productivity state.”

The holy grail, then, is to have access to AR wherever it is architects work, whether that’s at their desk, on-site, or at a client meeting. “Wherever you want to work without the anchors of physical objects, that’s really the most widely beneficial thing that we are exploring right now.”

AR, then, is the next generation of our ability to consume content. It is the optimal platform for consuming content while maintaining productivity and engaging with information. Instead of looking at computer, phone, or tablet screens, there is a future where professionals will not require screens and, instead, information will just appear in their field of view when they need it to. This means that the physical drivers that currently influence the way architects and designers work are already rapidly evolving and will exponentially change the industry the faster the platforms mature.

Even in adjacent industries like construction, Robles is already seeing the DAQRI smart helmet being used, which allows construction workers on-site to walk around and see the digital assets overlaid on the physical space. This also lets them see not only the present physical view, but also the future and past views of the space by overlaying timestamped plans they can click through. This makes things easier for job sequencing, clash detection, and problems before they’re built. It’s an extremely powerful use case.

Helmets and headsets are a little cumbersome, however, and it’s debatable whether professionals will want to constantly have a physical apparatus strapped to their head. Again, this comes down to platform maturity and where things are headed—no pun intended. Then again, rare is the person who doesn’t walk around with a smartphone almost permanently in hand today, and that need which the smartphone currently fills may soon be replaced by AR, portable and available quickly when we want it to be. Most people don’t walk around with smartphones held out permanently in front of their face, but having the option to quickly access it is paramount.

This will be the case for functional AR too, argues Robles. “You have to look at it in terms of accessing what we really need—whether it be just your voice or some sort of physical input—seeing it yourself, and having the ability to share it with others. People are going to love that, and I think that will be something that will be kind of hard to put down.”

AR still has a plethora of issues to overcome before it becomes as useful to an architect as auto-CAD or a slide-rule though. “The barriers are about accessibility to devices, as well as having devices that are free of compromise,” said Robles, noting that things like tracking and field of view (FOV) were still big issues for many devices. Performance is still offset by stability, and availability is still limited.

What’s on Robles’ wish list for the perfect architectural AR device? “I would want something untethered, with an onboard processor, with a really wide FOV as close to a natural FOV as possible, with great battery life, with the ability to connect to other devices and computers, and with even more computing power.” When that happens, architecture may never remember what life was like before. ●

DIY Augmented Reality Possible with a Simple 8-bit MCU

By JPaul Carpenter, Mouser Electronics

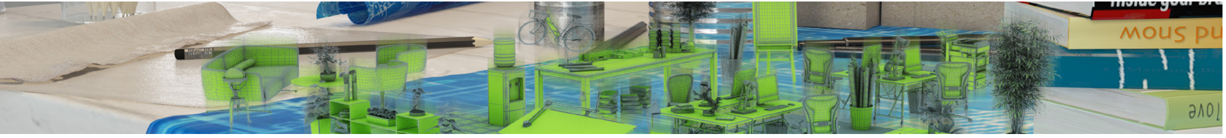
Many examples of augmented reality (AR) use Heads-Up-Displays (HUDs), which are transparent displays that present data without requiring users to look away from the primary viewpoint. But what is the underlying technology that makes seeing the invisible possible? HUDs still arrays of sensors, images, and networked information that's processed and analyzed to predict what needs to be displayed.

In a design marketplace that's heavily focused on the power and capability of 32-bit floating-point solutions, we shouldn't overlook the capability of the inexpensive and highly-capable 8-bit and 16-bit platforms. Their advantages will always be relevant even as they age, primarily because they are the tried-and-true solution. Additionally, they are very fast to develop, are relatively inexpensive, and capable.

A DIY 8-bit AR Solution

Looking at what is available today, most semi-augmented reality lies in smartwatch and smartphone displays to show message headers and weather. For this DIY AR solution, the core smartwatch and smartphone functions are needed to make a true AR form that overlays the augmented information.

Research into an 8-bit solution yielded an amazing find: Distributed computing, AR glasses that use 8-bit architecture and offer these capabilities:



- Low-level I/O
- Inter-chip communication
- Fast, reliable, low-level signal processing
- Bus adaptation
- Data processing using a high-level ARM, located on a smartphone

This approach identifies individual parts of the solution: Bluetooth module, Wireless interface, 8-bit controller, module for the Battery Management System, OLED display with a prism, and a gesture recognition module. Put it all together with some 3-D printing and voila an 8-bit solution that augments reality today.

“This approach identifies individual parts of the solution: Bluetooth module, Wireless interface, 8-bit controller, module for the Battery Management System, OLED display with a prism, and a gesture recognition module. Put it all together with some 3-D printing and voila an 8-bit solution that augments reality today.”

Bluetooth Module and Wireless Interfacing

The wireless portion of 8-bit architecture is usually very heavy and verbose, but that is simplified with a pre-configured Bluetooth low energy (BLE) module. The Microchip® Technology RN-41 is a good example, and it acts as a serial bridge in and out of a higher level system. It can function in a host or peripheral roll and supports GAP, SDP, RFCOMM, and L2CAP protocols without a host stack requirement, enabling this functionality within the confines of the ATMEGA’s Program and RAM limits. The simplicity of this device is that it allows the AVR to offload all of the overhead of Bluetooth, parse just the information that it needs to act on, and leave high-level processing up to the cell phone, making end-user configuration as simple as possible.

A wireless interface to enable data from sources other than a smartwatches and smartphones—such as temperature sensors and lighting with higher-level controllers—should come soon. Microchip is working on implementing protocols and standards for a wireless infrastructure to handle large amounts of sensors with LoRa. This protocol is ideal for large quantities of battery-operated end-node sensors to deliver and act on information, due to a coverage area of 15km and a battery life is more than 10 years.

Controller

At the core of this DIY solution is the ATMEGA328. This little MCU is the backbone that accepts the inputs from the speech recognition components, the Bluetooth UART, and finally, combines these instructions to output on the OLED display.

Battery Management System

The MCP73831 BMS is as always clean and requires very little input or output control from the MCU, once again allowing the MCU to primarily focus on the user interaction. Additionally, the BMS provides updates of battery charge indicators so that this information can be included in screen updates.

OLED Display and Gesture Recognition Chip

The OLED display is an amazingly simplistic method of communicating information. It accepts data over I^2C and displays it on the screen in a fashion that is very similar to a two-line display, except that graphics can also be displayed over the I^2C bus. Due to the brightness and high contrast that OLED’s are known for, the image can be reflected onto a mirror and finally into a prism allowing transparency and a full view of reality.

Additionally, the input was handled through a gesture recognition chip that was capable of recognizing up to six gestures: Tap, double-tap, forward, backward, up, and down. For the specific shared use case, the designer programmed the prototype to be very simplistic, yet it allows users to move through text and email headers by indicating left or right, view the weather by indicating up, and turn the display on and off with taps. With additional coding, more capability could certainly be added, but this is a great start, that truly shows what an MCU can accomplish best.

Conclusion

This entire project brings into focus the fact that so very often little focus is placed on the high capability of low-level chips and instead put entirely on the top level solutions, which are expected to do everything. Usually, this results in either a long development cycle or a shortened development cycle with a long debugging cycle, or a poor user experience, which could result in delays in development and thus launch. In contrast, this designer was able to move from concept and hardware selection to prototype in a very short time period, with a very low cost due to the advantage of distributed computing. The low-cost, low-power, rapid development, and reliability of the 8-bit MCU will continue to make it relevant and useful even when we are all reading articles like this on a headset. ●