AUTONOMOUS, CONNECTED & INTERACTIVE

TECHNOLOGIES DEFINING THE NEXT WAVE OF PRODUCT INNOVATION

E-BOOK

INTRODUCTION

There are many things that influence the product innovation process: the right mindset; the right culture; the right people; the right tools, solutions, and platforms. As important as all those components may be, what truly drives innovation is vision. Innovators envision something new and then strive to bring it into the world.

For a vision to develop, you need inspiration.

For a vision to be realized, you need to know what's possible. You need to know what tools are available to realize your vision. And you need to know what tools you may need to invent in order to do so.

In this brief, we hope to provide inspiration as well as a sense of the possible by looking at innovations in robotics, the Internet of Things (IoT), voice technologies, and augmented reality/virtual reality (AR/VR). There are several common threads linking these innovations: the ever-increasing intelligence and autonomy of manufactured objects, the power inherent in seamlessly connecting diverse systems, and the evolution of human interaction with technology.

Each of these innovations expands the boundaries of what's possible in industries ranging from consumer electronics to healthcare. As you think about their potential in your industry, what novel combinations and applications of technology can you envision? And how will this vision transform the products you bring to life?

SECTION ONE ROBOTICS

Improving Robot Dexterity Through Simulation

In 2019, a team at OpenAI finally achieved a goal they had been pursuing for two years: teaching a robot arm to solve the Rubik's Cube. There are several extraordinary implications of this feat as well as some practical lessons.

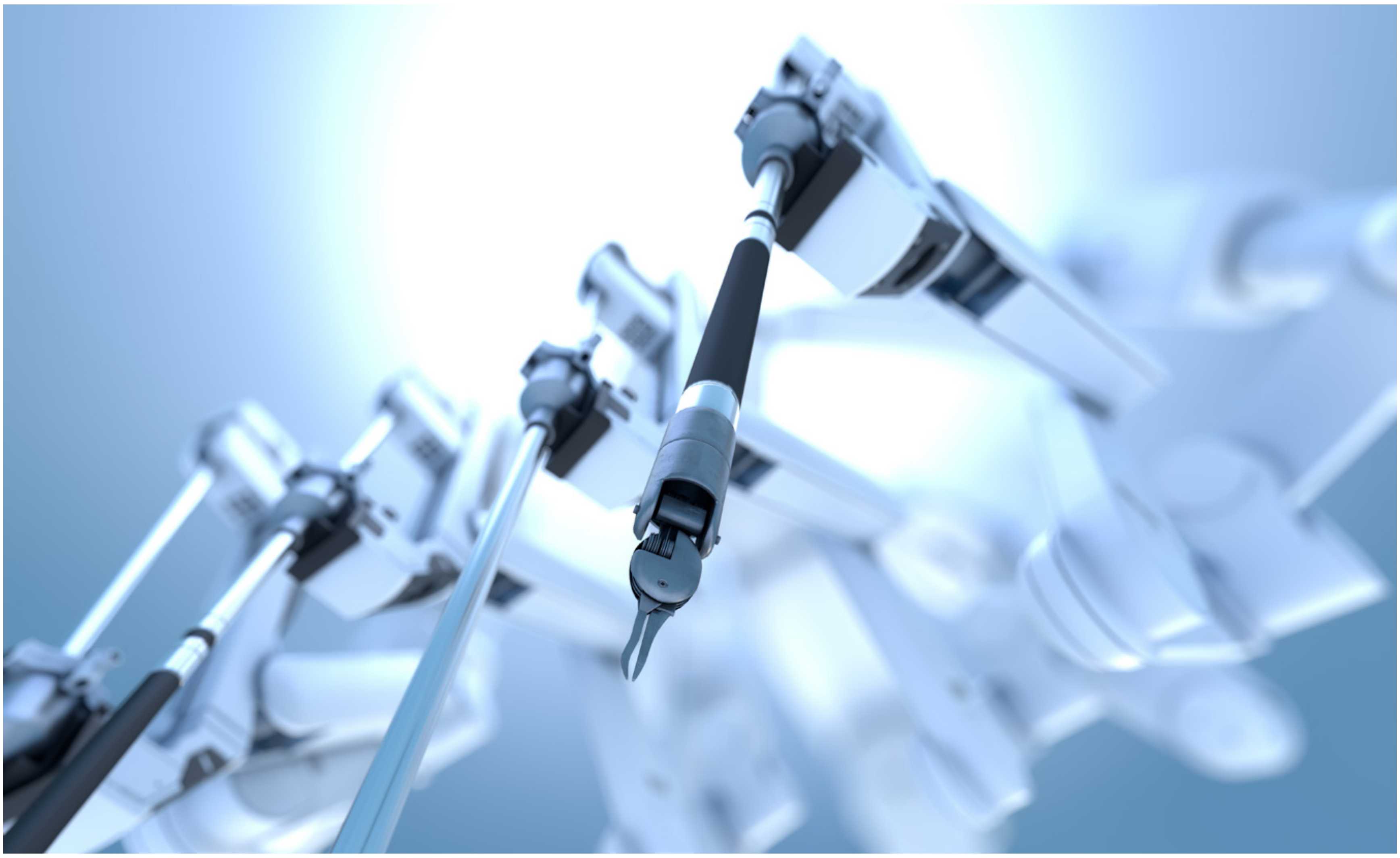
Robots have traditionally had a hard time with fine motor coordination.

While robots can be programmed to manipulate objects in a routine way, working on an assembly line, for example, they have, until recently, struggled to do anything as relatively simple as sort and place different shaped boxes and put them on a pallet or pick a pencil out of a pile of random objects. Teaching robots to master such tasks is critical to the eventual development of general-purpose robots. The level of dexterity exhibited by OpenAI's robot arm was an important step in this direction.

Interestingly, OpenAI taught their robot via simulation. While it has become common practice to train neural networks in simulations (including video games), there is an inherent problem in this approach: You cannot create a perfect model of the real world where the robot eventually has to operate. To address this issue, OpenAI relied on automatic domain randomization (ADR). That is, they employed an algorithm that automatically introduced random changes into the training simulation. One of the factors they randomized was the size of the Rubik's Cube. By introducing the arm to different sized cubes, they were able to teach the arm something about the physics of the actual cube.

This approach also prepared the robot arm to deal with distractions such as wearing a glove or being nudged by a foreign object as it worked on the cube. Researchers postulate that the ADR training "leads to emergent meta-learning, where the network implements a learning algorithm that allows itself to rapidly adapt its behavior to the environment it is deployed in."

> Learning how to learn provides a robot with a level of autonomy necessary to deal with the real world in all its unpredictability.



Vision Is Key for Robot Autonomy

Another key to robot autonomy is the ability for robots to visually navigate and interact with their surroundings. A good example of this is AEye's Intelligent Detection and Ranging technology, which enables vehicles to see, classify, and respond to objects in real time.

Improvements in vision have led to a wide range of robot-based applications, such as security (thanks to improved facial recognition capabilities), public safety (through the detection of potentially harmful objects in public spaces), and manufacturing (in quality control systems).

Computer vision and other forms of robotics are also having a revolutionary impact on healthcare. In one instance, scientists were able to train a neural network to read CT scan images and identify neurological disorders faster than humans can. In another, they trained an AI to more quickly diagnose certain cancers.

Beyond these powerful diagnostic use cases, we see robotics playing an even more direct role in patient care. These applications range from minimally invasive robotic surgery to remote presence robots that allow doctors to interact with patients without geographical constraint, to interactive robots that can help relieve patient stress.

> As systems become more and more autonomous and better equipped to navigate, manipulate, and interact with the world, the impact on product design and product innovation will be enormous.

This impact will be felt in terms of the level of autonomy consumers expect in their products as well as the level of autonomy we feel comfortable as a society building into our products. For example...

How many of us feel comfortable hearing the phrases "autonomous weapons system" or "autonomous police unit"?

As it evolves, autonomous technology will not only influence the types of products we produce, products which we will increasingly need to design either to interact with or enhance autonomous systems, but it will influence our architecture, our workplaces, and the urban environment itself.

SECTION TWO IOT

Understanding Product Performance Through IoT

The Internet of Things (IoT) is already massive. While estimates vary, in part due to how one defines IoT, there are already tens of billions of devices connected to the internet and capable of communicating with each other. Thanks to network effects, as the number of connected devices grows, the power of this technology grows exponentially.

The primary use cases for IoT, particularly in the industrial space, involve the monitoring and analysis of device performance in support of preventive and predictive maintenance, location tracking of vehicles and cargo, and the use of connected sensors to create “digital twins” of products.

This latter use case is particularly critical in product development because it allows manufacturers to use data collected from devices currently in use to optimize design and performance of next-generation products. Rolls-Royce is one company relying heavily on this use case to improve the design of its jet engines, for example.

Industrial IoT: The Rise of Platforms

As more and more companies invest in IoT technologies—the global market was $193.6 billion in 2019—we see major players developing platforms to support deployment and management of IoT resources. For example, in mid-2019, Honeywell launched Honeywell Forge, an Industrial Internet of Things (IIoT) performance management platform. It featured an open-API architecture that allows organizations to integrate data from multiple sources. Companies around the world have already leveraged this platform to improve everything from the performance of steel mills to the cybersecurity of major ports.

Honeywell Forge is far from the first IIoT platform offering, however. GE launched its Predix platform in 2013 and has continued to expand the platform's capabilities, most recently with the launch of Predix Manufacturing Data Cloud, "purpose-built to consolidate and transform manufacturing data across plants for enterprise cloud storage and analysis." The capabilities of Predix MDC allow enterprises the ability to ingest, analyze, and act on IIoT data more efficiently and optimize performance of "the connected factory." The Predix platform itself has found uses ranging from hospital operations management to airline fuel optimization.

From Gut Probes to Smartwatches: A Smarter Healthcare Experience

Healthcare organizations had already begun adopting IoT several years ago for maintenance and monitoring of physical operations. The next step was to apply this technology to patient monitoring, including using "smart beds" to let staff know when a patient had left their bed, or using wearables to track patient vital signs.

> Manufacturing, logistics, and service management are not the only areas in which IoT is driving innovation. We also see continued growth in the Internet of Medical Things (IoMT).

More recently, we have seen the development of "smart pills," that is, pills featuring ingestible sensors that are activated by stomach acids. These pills allow caregivers to ensure that patients have actually taken their medications. Similarly, doctors at Massachusetts General Hospital have developed a swallowable gut probe. The patient swallows the probe and then onboard cameras allow doctors to examine the health of the patient's gut, enabling them to quickly diagnose potentially fatal diseases such as environmental enteric dysfunction.

Of course, IoT now extends far beyond factories, service fleets, and hospitals. From Fitbit to Nest and beyond, IoT in recent years has become part of daily life. Cities have been using IoT to become "smarter" about energy usage, public safety, and traffic management. And in the face of COVID-19, healthcare institutions have been looking for ways to put the technology to use in gathering data to understand and potentially manage the pandemic.

From a product innovation perspective, there are two questions product designers need to ask themselves. On one hand, how might we perpetually transform and improve our products based on performance data gathered continuously from IoT sensors? On the other hand, when a product can communicate directly with its environment, what potential design innovations does this introduce? For example, if my luggage becomes autonomous, how does that change the material I use to make it? The handles, the compartments, the wheels? Thinking further out, how does this change closets, hotel rooms, and airports?

SECTION THREE VOICE TECHNOLOGIES ARE CHANGING PRODUCT INTERACTIONS

We've talked thus far about technological innovations that open up new possibilities for autonomous products and connected product ecosystems (from the factory to the home). We'll now turn our attention to innovations in the ways people interact with products.

Voice provides a natural way to interact with technology.

Voice-activated systems are already well-established in customer service and customer support functions (as anyone who has tried to navigate quickly through a voice-based system to report a problem with their cable company or renew a prescription can tell you). And both Siri and Alexa have made voice-based interactions with our devices commonplace.

But a demo of Google Assistant in the Spring of 2019 revealed what the future holds for voice interactions. Specifically, Google demonstrated that, using only voice commands, one could not only place phone calls, send messages, or set a calendar reminder, but also hail a ride, rent a car, reserve an airplane ticket, and more.

The implications of this are far-reaching.

Integrating Voice With IoT

First of all, voice is drastically changing how the web works. Today, e-commerce sites are built for humans. Indeed, user experience (UX) trends are helping optimize websites for human interaction. What Google Assistant demonstrates is that the days of human-centric websites are numbered. Instead, functional websites will need to be increasingly optimized for interaction with semi- or fully autonomous assistants.

This in and of itself will change the nature of customer experience and customer expectations. That is, one's experience as a customer will have less and less to do with a personal experience and more and more to do with whether or not a virtual assistant had a good "experience"— i.e., whether or not the assistant was able to complete its task efficiently.

Secondly, voice recognition and voice command technology, particularly when combined with IoT technology, will offer a range of new possibilities for product design. The most obvious uses are, first and foremost, in the home, where one can already use voice to dim lights, lock doors, and change the temperature. Voice commands can also be used in connected vehicles.

Volkswagen, among others, has already made it possible for drivers to use Siri to control their cars.

It doesn't stop here. For example, in the maintenance, repair and overhaul (MRO) space, voice-enabled applications are allowing maintenance workers to perform repairs while talking to a device itself, communicating with IoT sensors in the machine they are working on.

What's more, advances in voice recognition in noisy environments will allow for voice interactions with IoT-enabled devices even in loud factories or workshops. And German researchers have proposed ways for those working side-by-side with robots (so-called "cobots") to use these advances to allow them to control these robots via voice.

As people become more accustomed to voice-based interactions with their devices, cars, and homes, they will come to expect these capabilities in more and more of the products they use. Likewise, they will come to expect it from the technology they rely on at work. This means that product developers will need to consider how to voice-enable their products while also allowing them to rethink what a product might be capable of when the user can talk to it.

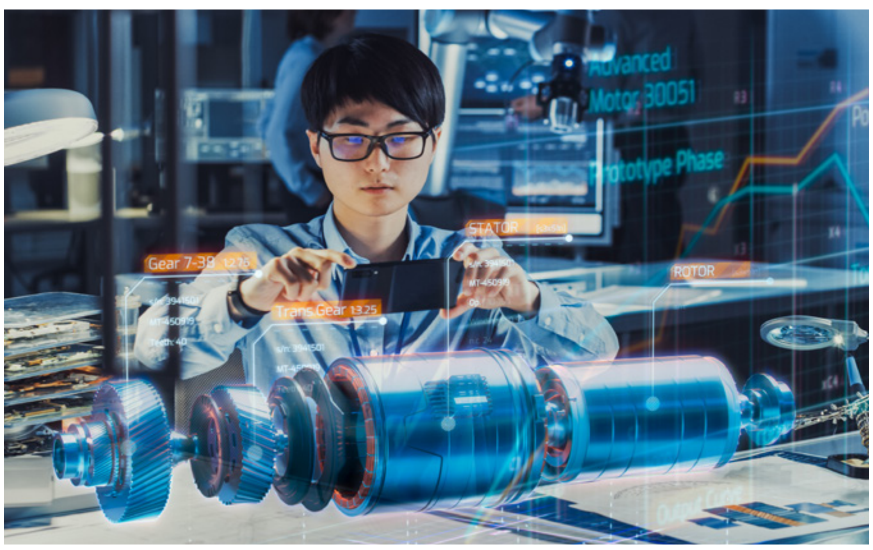
Application of voice commands and controls is not without its challenges, both from a technical perspective and a security perspective.

SECTION FOUR AR/VR SHIFTS THE BOUNDARIES OF PRODUCT EXPERIENCE

As natural as voice interactions can be for humans, we tend to rely on our sense of sight far more to navigate the world. For this reason, AR and VR applications will continue to have an ever-increasing impact on the way humans interact with their environments both at work and at home.

Augmenting How We Train and Work

Augmented reality, as the name implies, "augments" our experience of reality. It usually does this by overlaying information on the environment, either by taking advantage of the camera function of a mobile device or relying on microdisplays in glasses or goggles. This technology has already found a wide range of industrial use cases. First of all, it can be used in training. For example, Bosch teamed up with Re-Flekt to create an AR tool that could help train mechanics on the exact location of components in vehicles produced by Jaguar Land Rover without requiring trainees to remove and replace the dashboard.



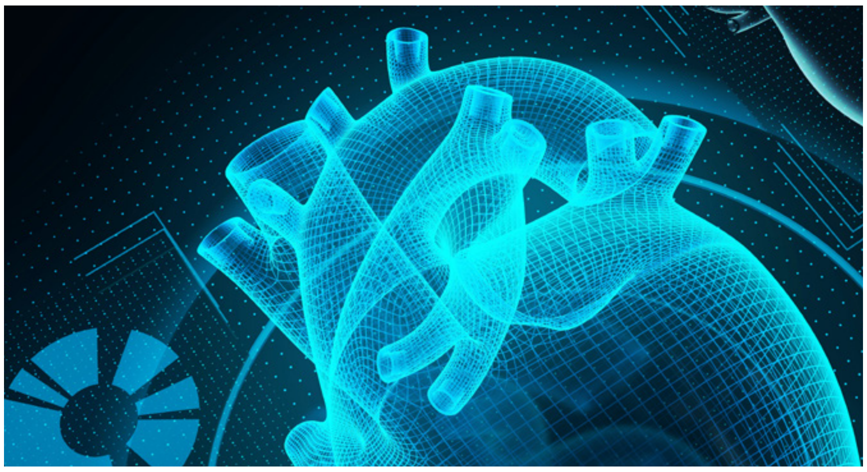
Additionally, AR can actually aid in conducting repairs or assembling complex machinery. To this end, Boeing has leveraged Upskill's Skylight tool to guide workers engaged in wire harness assembly in aircraft. By walking workers through the process as they do it, Boeing was able to cut production time by 25% and lower error rates to near zero.

The beauty of this approach is that AR tools can capture the work of subject matter experts as they perform a complex task, providing their colleagues not only with training materials, as in the case above, but also providing guidance as they actually complete the task themselves. What's more, you can also apply the same technology to things like QA, guiding QA techs as they conduct inspections and providing them with a way to record any defects or issues they discover.

> As with IoT, AR technology may prove a particularly valuable method of responding to COVID-19. Some companies are taking advantage of its training potential to provide remote instruction rather than the in-person approach that has been the norm.

Finally, thanks to advances in image recognition and other visual systems, as we discussed in the section on robotics, companies can use AR to help workers find things in warehouses and even identify spare parts. These applications have also found uses in retail environments. For example, Bell Integrator, which launched an AR platform in 2017, developed an app for an auto parts chain that allowed customers to identify the replacement parts they needed simply by viewing their vehicle through the app.

AR has also established a foothold in healthcare, providing doctors and other practitioners with tools allowing them to "see" a patient's vascular system—allowing for greater accuracy when drawing blood or starting an IV—or visualize tumors in 3D. As was the case in the industrial space, AR is being used for training in healthcare as well. Physicians can use AR headsets, for example, to be "telementored," whereby a remote surgeon can watch a surgery as it is taking place and provide the acting surgeon with real-time guidance. Similarly, physicians can use these headsets to record what goes on in the OR, coordinate OR staff, and assess surgeon performance.



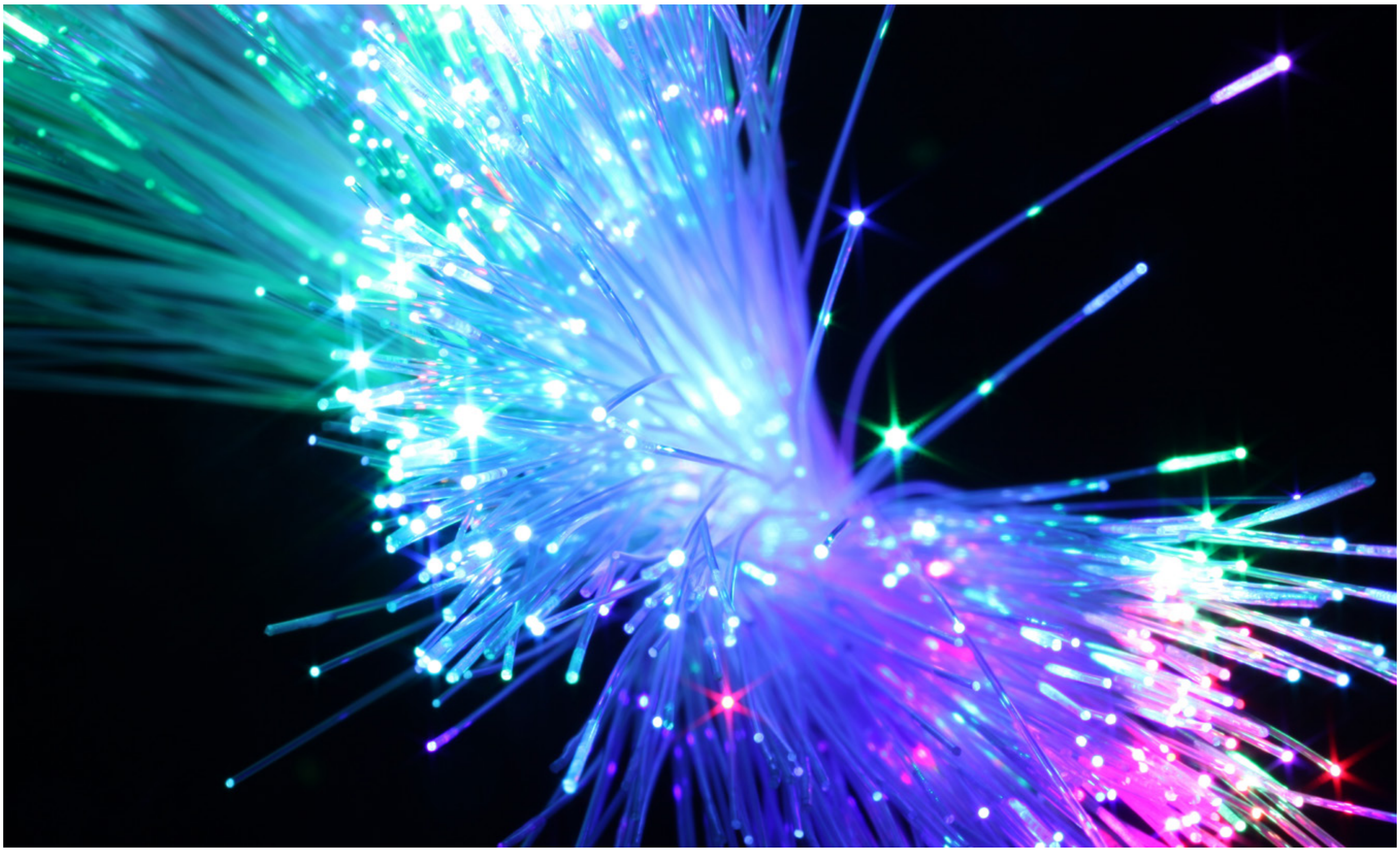
Advancements in VR

While still in its infancy, VR is also having an impact in healthcare. Specifically, research is currently being conducted on training surgeons using VR. Research conducted at UCLA involved using VR to train orthopedic surgeons on repairing a bone fracture. Students who went through the VR training were able to complete the surgery more quickly and follow protocols more closely than their traditionally trained counterparts. On another front, researchers at Cedars-Sinai Medical Center in Los Angeles found that VR could help patients manage severe pain, using VR games to distract patients during painful procedures.

VR applications in manufacturing and product design also continue to evolve. On the one hand, you have use cases such as leveraging IoT data to create explorable models of everything from individual machines to entire factories.

On the other hand, you have the use of VR as a proving ground for new product designs. We saw this above in the case of simulations being used to train the robot arm, but this use case has unlimited potential when it comes to evolving product designs based on responses to an endless permutation of environments.

As AR and VR become more established as media, they will continue to influence product design and innovation. And they will prove even more powerful when combined, in novel and unforeseen ways, with the other technologies we've described.



WHAT'S NEXT

We've shared these many technical innovations both to inspire and encourage you in your own innovation journey. As products continue to get smarter, even to the point of autonomy, they will necessarily become more complex, combining mechanical, electrical, software, and firmware components in ever more sophisticated ways. Not only do these components need to work in unison, but they will increasingly be designed by dispersed teams and depend on collaborative, global supply chains.

To manage this complexity and support continuous product innovation, companies need a single, secure source of truth. This is the only way to ensure that all departments—from engineering to quality to manufacturing—are aligned and working together, from start to finish.

Solving complex product development issues is what Arena was designed for.

EDITOR'S NOTE: Arena prepared this brief as part of an effort to shed light on the innovation process for forward-looking companies. Given the unprecedented disruption currently confronting all businesses, we revisited this document to see what elements required modification to align with the new circumstances. While it is impossible to take full measure of COVID-19's impact, we believe the initial brief retains its relevance in today's climate. Our hope is that you and your company will find it valuable as you find a way forward and bring new visions to light

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