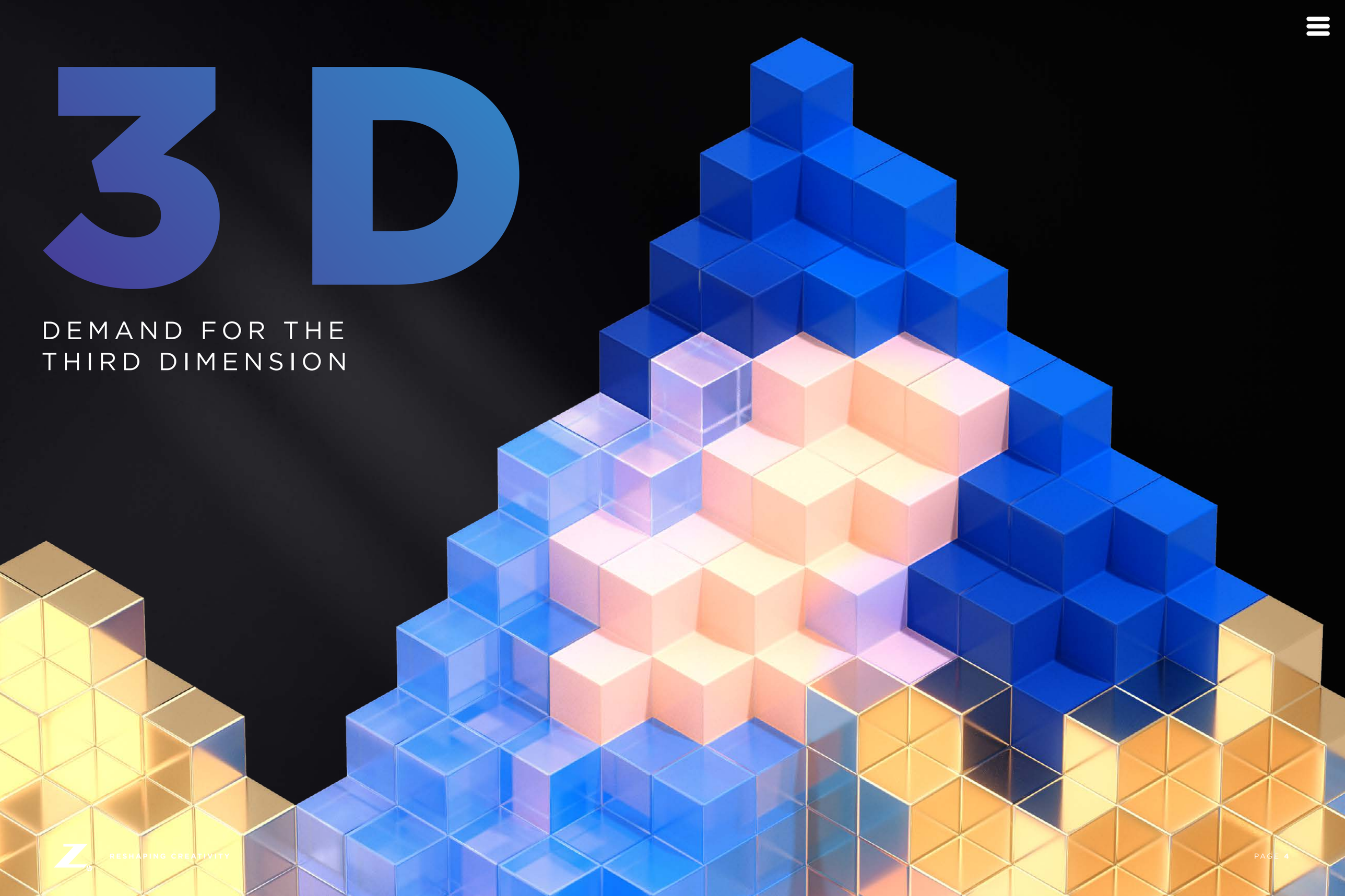
3D

DEMAND FOR THE
THIRD DIMENSION



Few modern technologies are as pervasive as 3D. From 3D gaming and visual effects-heavy Hollywood blockbusters to manufacturing and fashion, 3D graphics can be found playing a pivotal role in a wide range of products, technologies, workflows and industries. Since 3D is about modeling and simulating objects in a digital environment, it's increasingly used for visualization everywhere.

3D's ubiquity is, in part, what's fueling its growth. The global 3D animation market was valued at nearly $14 billion in 2018 and is expected to grow at a compound annual growth rate of 11 percent at least through 2025, according to Grand View Research.[1]

Some industries are in the throes of massive transformation. While those in manufacturing, for example, have used 3D for decades, other industries, like fashion, are just beginning to see the benefits of 3D across the entire workflow. Artists who have traditionally needed to wait hours or days for complex scenes to render can now create photorealistic visualizations in minutes. There are few businesses that can't benefit from these efficiencies.

REAL-TIME RENDERING TRANSFORMS WORKFLOWS

Traditionally, the costliest resource for creating high-quality visualizations was time – rendering time. "The availability of computational power has changed everything," says Sébastien Deguy, Vice President of 3D and Immersive at Adobe. David McGavran, CEO of Maxon, elaborates: "The success of GPU renderers like Redshift have changed the time calculation exponentially for rendering amazingly detailed scenes in minutes which used to take hours or days." Photorealistic renderings can be created at 24 or 30 frames per second with

$14B

MARKET VALUE OF 3D ANIMATION

1 https://www.grandviewresearch.com/industry-analysis/3d-animation-market

no discernable delay. These astounding advances in hardware performance are being paired with real-time graphic engines, which got their start in the computer gaming world. Unreal Engine and Unity are well-known as the engines driving the graphics across a range of games with hundreds of popular titles in between. But nothing about rendering engines are gaming specific. "This technology came from gaming, but it's being applied everywhere," says Ross McKegney, Director of Engineering for 3D and AR at Adobe.

Hollywood is embracing these real-time rendering tools, and for good reason. In the 2000s, directors shot actors in greenscreen environments and surrounded them with rich 3D environments. But advancements during this time only allowed for rudimentary ability to pre-visualize the scenes that were being shot digitally. With modern real-time rendering, directors see photorealistic visualizations of the scene in the camera, giving them the ability to see what the finished film will look like even as it's being shot. VFX studio The Mill[2] has been combining real-time rendering with motion capture in innovative ways to allow clients to create fully realized content in real time. In the past, if you wanted a computer-generated creative to appear in a video spot, that might take months to script, shoot with a motion-captured human actor, and then render. Need to reshoot? Repeat the process.

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> Director of Engineering, 3D and AR, Adobe

The Mill, however, motion captures an actor and renders it photorealistically as a fully-realized CG character as it's recorded, reducing the workflow from months to hours. The CG character responds instantly to motion-captured action in front of the camera, so the director and clients can see exactly what they're getting without weeks of post-production.

And then there's the same studio's Cyclops toolkit, which, when combined with Unreal Engine, allows a producer to insert a photorealistic rendered automobile into fast-paced road race footage. By shooting a placeholder vehicle covered in markers, it can be "skinned" by compositing any other vehicle over it in a convincingly undetectable way.

2 http://www.themill.com/

PHOTOGRAMMETRY COMBINES THE REAL AND THE VIRTUAL

Once you build 3D models, though, how do you create the world in which they live? Certainly, 3D environments can be built from scratch, but it's incredibly expensive and time-consuming to create that content. Photogrammetry – the ability to reconstruct 3D models from photographs of real objects and scenes – is emerging as a powerful tool for automating the creation of 3D worlds.

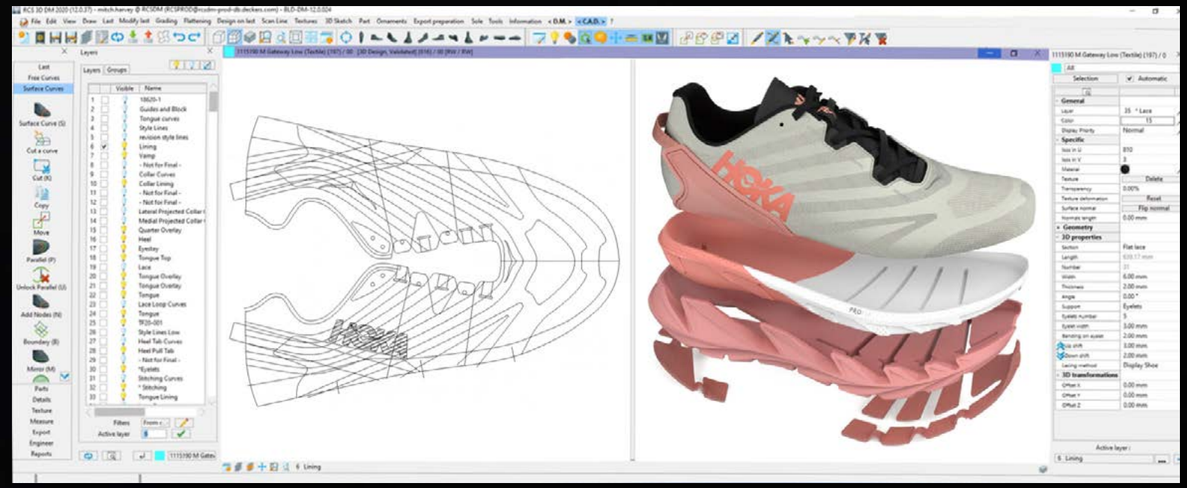
"What we want to do is capture enough of the real world so that we can represent all of the real world virtually," says Marc Petit, General Manager of Unreal Engine at Epic Games. "We're not going to scan all the rocks on the planet, right? That would be highly impractical. But we can scan enough rocks that using machine learning techniques, we can generate all the rocks that we want, which are going to be all different." Last year, Epic Games acquired Quixel, a leader in photogrammetry, and has made tens of thousands of photogrammetry-based digital assets available to artists for free.

This technique is used extensively in film, and in other applications as well, such as architectural renderings.

3D GOES MAINSTREAM

The final element responsible for moving 3D into the mainstream is the emergence of Physically Based Rendering (PBR), which defines textures and surfaces in 3D models based on physical properties. "Before PBR, to render an image, you'd have a programmer actually write code to define how a scene would be rendered," says McKegney. "It was a very technical job. With PBR you're putting that in the hands of a designer who can create models by specifying physical properties. It's much more efficient than writing custom code."

This one development has enabled countless businesses to build 3D imaging into their product development, design, and marketing workflows; photorealistic textures can be applied by designers as a part of the creative workflow.



Fashion brand Deckers designs their footwear using 3D modeling software, allowing for precision and efficiency during the manufacturing process.

Chris Hillyer, Innovation Director at the fashion brand Deckers, is spearheading this kind of 3D transformation for the creation of footwear. "I'm just adapting technologies that are being used in other industries with great success," he says. Under Hillyer's leadership, Deckers has moved to a digital-first design philosophy, creating footwear in 3D modeling software and then striving to capitalize on the efficiencies that come from using that design through manufacturing, sales, and marketing. This workflow is only possible thanks to the intersection of computing power, real-time rendering, and shifting roles from specialized programmers to creative designers.

Part of Hillyer's challenge is moving away from the sluggish and error-prone workflow of years' past, when footwear designs were created on paper and then sent to manufacturing partners in Asia. "We'd cross our fingers and hope they understood our vision. We'd hope they could interpret a side view picture of a shoe and magically make it three-dimensional," Hillyer says. These days, that dynamic is turned upside down – starting with a 3D design, the manufacturer is now fully equipped for success. The 3D design gives precise information about the materials needed, and any changes update on the Bill of Materials automatically.

The efficiencies extend well beyond manufacturing. "If you have 17 colors of a given boot, you can make one of them and represent the rest of them in 3D, so you don't have to ship thousands of samples around the world anymore," says Hillyer.

When it comes to modeling real-world objects, especially in worlds like fashion and home design, accurately representing textures, fabrics, and other materials is critical. 3D developers are already meeting that challenge. CLO 3D,[3] for example, is a 3D tool that lets designers create and visualize 3D versions of clothing – even seeing how it flows over the human form. A similar tool, Browzwear,[4] works in conjunction with the Fabric Analyzer, a device that precisely measures the thickness, stretch and bend properties of fabric, which can be used by 3D design software to accurately model exactly how the fabric will behave on a real person.

VR OFFERS A WHOLE NEW VIEW

For decades, our interactions with computers have been flat – we've worked, played, and been entertained through a two-dimensional screen. Even when content has been depicted as three-dimensional, it was necessarily displayed on a flat screen. Those days are ending – the future is shaping up to be truly three-dimensional.

3D has begun to enter the mainstream for both consumers and commercial applications through virtual reality (VR), a stereoscopic experience that simulates a fully immersive depiction of a 3D environment. A variety of factors, including the development of GPUs sufficiently powerful to render real-time stereoscopic visuals and

3 https://www.clo3d.com/
4 https://browzwear.com/

an explosion of commercially available VR headsets, are putting VR in reach of most users.

That's a dramatic shift from just a few years ago, when cutting edge creators who wanted to explore VR were forced to literally make their own hardware. Nonny de la Peña, Founder and CEO of Emblematic Group, recalls the complexity of creating Hunger in LA, a VR project she led in 2012. "Thank God, I don't have to make physical gear anymore," she says, recalling that she once had to source her own lenses, 3D print her own goggles and purchase tracking cameras in order to cobble together equipment to show her creation at the Sundance Film Festival. When she started it was a fertile time for the nascent VR industry, though; future Oculus founder Palmer Luckey was an intern in the University of Southern California lab where de la Peña was a research fellow.

Now, creators can rely on a variety of commercially available hardware, and that's helping drive VR forward. As a journalist, de la Peña thinks about VR in terms of its visceral impact on users. "There's nothing like it. VR has this really interesting way of engaging with both parts of our brain – the part that makes us feel like we're there and the part that knows we're not there. That duality of presence, of being there and knowing you're here at the same time, is why it's such a powerful medium to work with."

Certainly, immersive journalism like de la Peña's is only one application of VR; even larger uses for VR include gaming, marketing, and even commerce. Andi Mastrosavas is Chief Product Officer at Insperience, a company that's developing VR-powered retail experiences. She sees 2020's global COVID-19 pandemic as helping to accelerate VR's adoption, particularly in retail experience. "Right now, we know there are no real commerce VR experiences to speak of," says Mastrosavas. "To use online video as an analogy, we're pre-YouTube." Mastrosavas says she used to imagine a timeline of five to seven years before people would routinely embrace retail experiences in VR at home. "I think that's now been condensed to three years."

Shailendra Mathur, Vice President of Architecture at Avid Technology, looks more broadly at VR's role in entertainment, and sums up the imperative for VR this way: "I believe there's going to be a point where we won't be satisfied with entertainment until we can offer an alternate reality that matches how our senses work.

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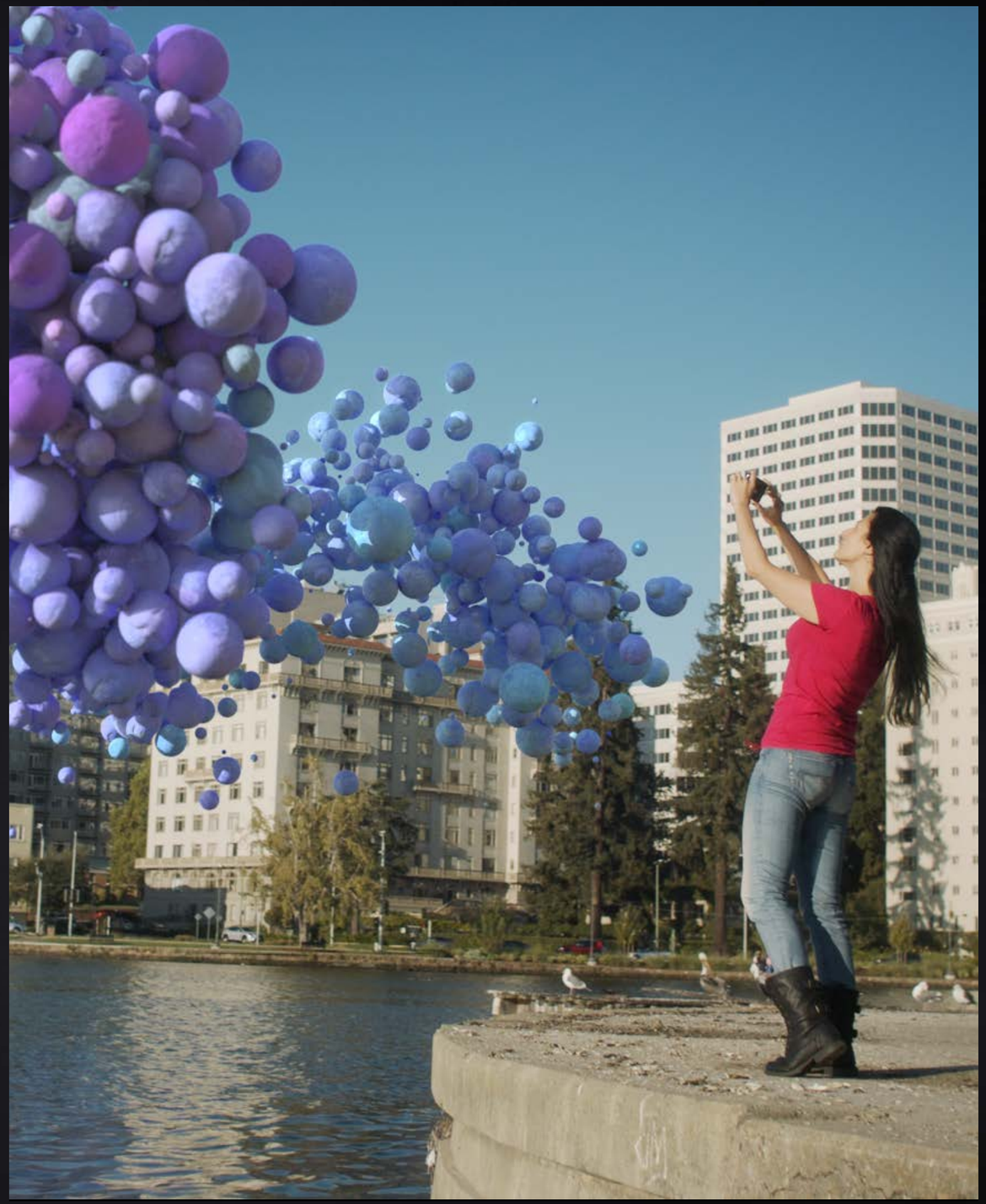
> **NONNY DE LA PEÑA**
> CEO and Founder of Emblematic Group

REACH, an Emblematic Group platform, lets users place real people into high-res 3D environments, like the one pictured above.



Adobe Aero enables users to view, build, and share immersive and interactive AR experiences.

> "There's going to be a point where we won't be satisfied with entertainment until we can offer an alternate reality that matches how our senses work."
>
> **SHAILENDRA MATHUR**
> Vice President of Architecture, Avid Technology

Viewing through two eyes is the natural thing to do, and Stereoscopic VR takes us into the next level; it's a wholly immersive experience."

Getting there will have its challenges. Despite its potential, VR hasn't instantly become a mainstream consumer technology. And despite advances in headset technology, VR hasn't yet reached its potential. Concerns about cost still prohibit mass adoption. And in retail or social environments, the nature of a VR headset can feel isolating.

XR IS REALLY THE FUTURE

Moreover, VR may not have taken the world by storm because it's only part of the story. The real future of 3D interaction is likely to be Augmented Reality (AR) and its close cousin, Mixed Reality. Manufacturing is one of many industries exploring applications for AR in tasks like safety, training, logistics, and maintenance.[5] "I truly believe that AR will eventually be everywhere," predicts Deguy. "Right now, VR is more representative of what the AR experience will eventually look like, after we solve the hardware problem about how to display it without hardware getting in people's way."

Says de la Peña, "I would use the term XR or extended reality instead of VR because when you create things spatially, you can explore them as either a virtual reality or an augmented reality experience. I think that the idea of the separation between those two technologies is going to go away."

AR technologies already give designers the ability to place virtual objects in the user's field of view, mixing it with real-life environments. Consider Adobe's Project Aero,[6] for example, which is now available to customers in early access. Objects designed in Photoshop can be exported to an AR app with a click – like sending a file to prepress – where clients and customers can use their phones to see the object appear in full 3D in whatever physical environments they're standing in. It's akin to instant 3D printing.

And by equipping computers with an understanding of the local environment mapped in 3D data, virtual and real objects can interact within AR headsets. Digital objects can be placed on a real tabletop, for example, and a headset can maintain the illusion that virtual objects exist in the same space as real ones. Using tracking devices and sensors, users can perceive physical objects differently in the virtual environment, and fully interact with them. This, in a nutshell, is Mixed Reality. When the computer can digest the real world as 3D metadata, there are few limits to how the real and virtual can interact.

That's opened up some exciting new possibilities. Volumetric capture solutions like 4D Views' Holosys[7] can scan and render real-world objects into AR environments in real time, enabling the insertion of physically distant elements into an interactive video, or creating a "hologram" in which users carry on a two-way video conversation with someone as if they're in the same room as perceived through AR goggles.

Spatial computing takes these concepts one step further. Over the last decade or two, interactions with computers have become more natural and human-centric. We've gone from arcane text input to mouse and keyboard control to gestures on a screen. Spatial computing allows gesture control – currently really only practical in VR – to happen in the 3D world, so users can interact with virtual interfaces and objects just by reaching out and touching them. And spatial computing won't stay strapped in VR

5 https://blog.thomasnet.com/augmented-reality-manufacturing
6 https://www.adobe.com/products/projectaero.html
7 https://www.4dviews.com/

> “Having designs in 3D allows brands to market things while they’re still being manufactured.”
>
> **SARAH KRASLEY**
> CEO of fashion brand Shimmy Technologies

forever, either. Already, wearable devices like Litho[8] allow users to interact with digital objects in the real world.

CHALLENGES AND OPPORTUNITIES FOR 3D

All of this potential comes at a cost. Traditionally, aspiring designers have found 3D design training difficult to find, which often required a degree in traditional design, followed by hands-on experience in industry. There was no obvious pathway to jump directly into 3D. “You had to learn from other people around you, and the people that were doing it at that point weren’t really doing an amazing job at it. It was really just a lot of trial and error,” recalls visual artist, director and Z by HP Ambassador Shane Griffin, who has directed videos for brands like Apple, Google, Microsoft, and Adidas. But access to 3D design tools and education is improving.

Shimmy Technologies[9] is a fashion technology company whose mission, in part, is to prepare garment workers in Bangladesh to make the transition to 3D. Despite the fact that these workers are not often computer literate, Shimmy helps them level up their 3D skills. “We built a little video game that up-skilled garment workers’ basic digital skills and transferred what those workers know about physically making garments on the factory floor to digitally constructing them in 3D models,” says Sarah Krasley, Shimmy’s CEO.

Shimmy did that by building an interface that let them take what they already knew about making clothing on a sewing machine and applying that knowledge to doing highly valuable digital 3D work. “This work would not have been possible without artificial intelligence,” Krasley says, explaining that the software communicates in the Bengali dialect the workers speak. The result? Many of these workers have advanced into roles that pay 250% of what they were earning before.

The changes aren’t just happening in Bangladesh. Real-time interactive 3D design is no longer an unusual career to which artists must migrate laterally from traditional design studies. Unity, for example, has released a pair of tools – Create with Code[10] and Unity Teach[11] – for classroom education. Unity Teach is a platform that supports educators who want to expand their skills teaching STEM topics, while Create with Code is a complete set of courseware for learning to program in Unity, including teacher modules, tests, and answer keys, and students can then apply for the Unity Certified Programmer Certificate.

Even as 3D explodes into the mainstream, powered by better tools, more educational opportunities, and an ever-expanding universe of applications for 3D to be applied, the very success of the technology is starting to create some challenges. All the way back in 2004, a film was criticized for crossing into the Uncanny Valley – that point in visual fidelity where CG characters are so lifelike yet not lifelike enough that they trigger warnings in the back of our brain that there’s something wrong with what we’re seeing.

But even that is changing. Siren,[12] a real-time digital woman created by a partnership of studios including Epic Games and CubicMotion, is arguably indistinguishable from a real person. Siren’s face – including eye movements, facial expressions, and skin texture, elevate the state of the art and imply the Uncanny Valley is, in fact, thoroughly passable.

IMPLICATIONS

The field of 3D is crackling with innovation, because it is so incredibly pervasive, with artists and designers eagerly embracing it.

Traditional 2D industries – even ones like fashion, which have traditional workflows that date back millennia – are transitioning to 3D. “3D affects the industry in so many ways,” says Krasley. “Being able to prototype digitally saves a lot of time. Having designs in 3D allows brands to market things while they’re still being manufactured. And if you have a 3D model that you’re using for marketing, you can use them to lay out how you’ll set this out in the store. There’s some CAD platforms that allow you to have a fashion show so you can see what this stuff will look like on a catwalk in motion.” And eventually, Krasley says, “these same models will be useful in the AR and VR experience for the end user shopping experience.”

But all those applications for 3D within any single industry suggests looming standards issues that must be resolved, sooner rather than later. Hillyer agrees: “I sit on a couple of different innovation boards within the 3D Retail Coalition. As an industry, we’re trying to standardize how materials are scanned and stored, along with all the associated data that goes along with describing a material.” To that end, Hillyer has been developing an online platform called Material Exchange,[13] which can serve as a standard platform for companies across the fashion industry to securely scan and store the digital representations of materials.

These kinds of standardization conversations are happening across industries that are embracing – and stumbling into the complexity of – adopting 3D. And just in time, too, because with the progression of real-time rendering, mixed reality, and the growth of 3D across every conceivable industry, it’s just a matter of time before everything in the real world will have a digital twin -- its own set of 3D metadata to be consumed by 3D software and display technology.

8 https://www.litho.cc/
9 https://www.shimmy.io/
10 https://learn.unity.com/course/create-with-code
11 https://unity.com/learn/teach
12 https://cubicmotion.com/case-studies/siren/
13 https://material-exchange.com/