Eccescopy: To look, is to see

Creating a future where dreams walk among us.

By Ken Perlin

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In 2003, I visited Will Wright at Maxis, while he was still working on "The SIMS 2." He showed me a box—exactly the size of a computer game CD box—with nice artwork, text, and system requirements. It was everything you'd expect, except it was labeled "SIM Everything." The release date was 10 years in the future. I looked more closely at the system requirements, and they were far beyond anything that was available then. Will explained this was always the way he and his colleagues planned new game releases. Right up front they design the box, the artwork, the characters, and the nice little blurb that goes on the back of the box.

Turning the CD box over in my hand, I said, "So the box is actually empty?" "No," he replied, "The game is already in the box. You just can't open it yet."

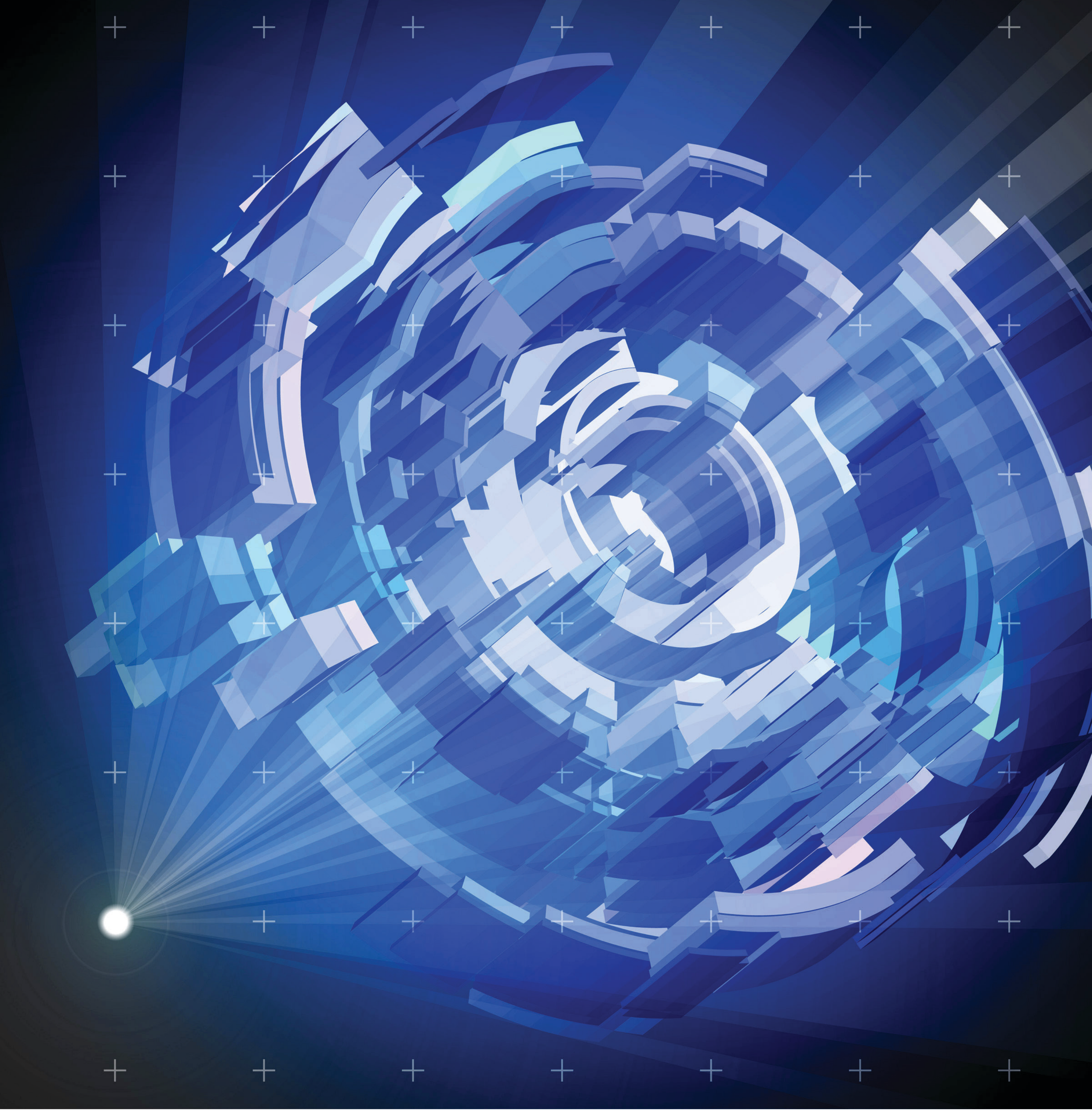
A few years later I read Vernor Vinge's novel, *Rainbows End*. I realized everything in it would be attainable in the next few decades. Computer screens will become superseded by wearables and eventually by contact lenses. People will become used to seeing virtual objects superimposed onto the physical world. Each of us will have our own personal view of this augmented reality. I call this sort of display "eccescopic," from the Latin "*ecce*" and "*scope*." To look is to see.

Will it be a good thing or a bad thing when virtual objects appear to inhabit physical space? And how will it affect our relationship with the world around us? Will eccescopy take us even further away from physical reality, or will it allow us to better join mind and body?

ECCESCOPY IN POPULAR CULTURE

Of course, the dream of merging the real and the virtual is far from new. Visions of an eccescopic reality have a long history in popular culture. These visions often highlight real killer apps for eccescopy: Enhancing the ability of people to communicate with each other without disrupting their sense of shared physical space.

For example, in the 1957 film "Forbidden Planet," a machine developed by the fictional alien race The Krel



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allowed its user to project virtual objects into thin air merely by thinking of them. Twenty years later, the first "Star Wars" film showed something vaguely similar: An eccescopic depiction of Princess Leia in a beam of light. Ten years after that, "Star Trek the Next Generation" introduced the Holodeck, a completely immersive alternate reality in which everything could be eccescopic.

The 1999 film "The Matrix" presented the ultimate extension of this idea. In the film, a simulation replaced the physical world. Life was lived entirely within cyberspace. In such a constructed world, nothing is real, yet anything becomes possible. People can have superpowers, and objects can change form or even disappear instantaneously.

Yet a direct-brain interface like the one in "The Matrix" turns out to be quite difficult to create. The problem isn't the physical connection of electrode arrays to brains. That's difficult, but not impossible. In the next 20 years, direct brain/computer interface technology is likely to advance far beyond what we can do today. Science has already advanced considerably in this direction. No, the basic problem is your perception of reality is already a construct—one maintained by your brain. For example, you don't literally see things the way a camera does. At any moment in time, your eyes perceive only a tiny window into reality from which your brain then constructs a plausible model. It is really this constructed model that you "see." We don't know very much about how this construction process works, which means we can't hack into it with any effectiveness. And even if we could, a direct brain interface like the one in "The Matrix" would need to replace the considerable amount of image processing done by our optic nerve. We might also need to simulate the saccades and other movements made by our eyeballs as our brain continually refocuses its attention.

The most reliable way to transmit visual information to the brain is in the form of visible light. Why invent something new, when you already have something as powerful as the human retina?

ECCESCOPIC PROTOTYPES IN THE LAB

Around 2002, our research group at NYU developed an early prototype of Holodust—a kind of eccescopic display, which created virtual images of 3-D objects directly onto a cloud of dust. Since you can never know the exact position of each particle in a cloud of dust, our scheme used two scanning lasers: An infrared laser to sweep through the cloud looking for dust particles, as well as a visible laser along the same optical path that could flash on command. This dual laser approach gives the ability to "paint" a 3-D shape onto individual dust particles floating in the air.

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Whereas Holodust creates a glowing image of an object that seemingly floats in thin air, the 360 degree Light Field Display at USC is more eccescopic, because it allows the shading of a virtual object to change as it is seen from different directions. Unfortunately, that technology relies on a slanted metal mirror rotating at a very high speed. If you tried to touch it you would most likely destroy both the display and your hand.

THE FUTURE EVOLUTION OF ECCESCOPIC TECHNOLOGY

Charles Darwin observed every genotype requires a viable phenotype. That is, no mutation can survive unless it can produce viable offspring. Technology is like biological evolution in that it can't just magically jump far ahead. Every step along the path to innovation needs to be useful, otherwise it will die in the marketplace before enabling the next step.

For example, I don't think we will first achieve widespread eccescopy through surgery. Yes, technically we could give everyone an artificial lens implant, but until there is a good reason for such an intervention, people won't do it. It's not even that invasive eye surgery is so exotic. You probably know many people who have had cataracts and are walking around today with an acrylic lens implant or two. You don't know who they are, because it's not something people generally talk about. The operation itself is relatively simple and safe, requiring only local anaesthetic and no stay in a hospital. But it's only done because it avoids blindness. A very different value proposition than, say, implanting an artificial lens so you can do Google searches within your eyeball. Most people won't opt for invasive surgery unless it helps them to be more "normal," however that word is currently defined in their culture.

Not too long ago, putting an electronic auditory enhancement device in your ear was something you did surreptitiously. A hearing aid was something you tried to hide—ideally you didn't want anyone to know you needed one. Recently there has been a fascinating trend in the other direction. A hearing device on one's ear may now be perceived as a source of empowerment. In the case of bluetooth hands-free cellphones, people don't try to hide these devices, they try to show them off. I think the key distinction here is between "I am trying to fix a problem" and "I am giving myself a superpower." The former makes you socially vulnerable, whereas the latter makes you socially powerful.

Yet the thing that strikes me about both of these set-ups is they interfere with eye contact. In both cases, you cannot look directly into the pupil of the person wearing the head-mounted display. The pupil is hidden by the display mechanism, which is literally in the way. Something tells me this is a show stopper for widespread adoption. When looking at another person face-to-face, most people want to see their eyes. I suspect retaining the ability to see other peoples' eyes will be necessary for widespread acceptance of an eccescopic future.

LIFE IN AN ECCESCOPIC FUTURE

How different would things look in an eccescopic world? As different as books on paper and the Web. Instead of a world of computer screens (even the little screens on smartphones), imagine a world where information is truly in the air around you. First, eccescopic interfaces will allow us to interact with other people directly, without any screens getting in the way. Second, they will allow us to "paint" and otherwise annotate the physical world around us in ways that are visible only to some people and not to others.

Let's take the first point. Suppose we are having a conversation about American history, and a question comes up, such as: "What was the name of Thomas Jefferson's wife?" In today's world, at least one of us would need to break eye contact with the other to type a query onto a computer screen. Meanwhile, the other person is probably also visually disengaging—since it is impossible to maintain eye contact with a person who is staring at the screen of their phone. But if we knew the entire search transaction—both query and response—was accessible wherever we already happen to be looking, then there would be no need to break eye contact. We would develop ways to query a computer that do not require loss of eye contact. In an eccescopic world, "eyes free" methods of entering text might become not only socially acceptable, but socially necessary.

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That leads to the question of privacy. One objection to everyone having their own eccescopic display would be the loss of personal privacy within the public sphere. Wherever you go on a city street, somebody will be sure to record you, and those recordings can be pieced together to track your every movement. Yet there are times when even this can be a good thing.

For example, in 2003, like many New Yorkers, I attended a protest of our then president's decision to go to war against Iraq. New York City police routed the crowd of protesters in a very odd way. We were shunted off into various side streets, eventually quite a few of us found ourselves penned in when policemen on horseback charged into the crowd. For the unfortunate people in front, there was no way to avoid the kicking hooves of the horses. The next day, national newspapers printed the NYPD's description of the incident: Hostile protesters attacked police horses, and the police had done their best to protect the helpless horses from the dangerous and unruly mob.

That was 12 years ago. Today the police couldn't have gotten away with a stunt like this. Too many people in the crowd would be carrying smartphones, each with the ability to instantly upload images of what really happened before the police had a chance to take the phones away. In an eccescopic world there would still be private spheres, and we would do well to protect them. But one could argue a democracy best flourishes when its shared public spaces are exposed to the light, not when they are shadowed in darkness and fear.

Then again, the more we build our interaction technologies into our own bodies, the more vulnerable we become to perception hacking. Once computer technology is used for perception of the world around us, then our senses become vulnerable to being hacked. Our eyes might see things that aren't there, our ears might hear things that don't exist, or our fingers might touch objects that are not real. An entirely new field might arise; a field of security that protects you from having your augmented reality replaced by a chimera.

CONCLUSION

Of course you never really know how the future will unfold. As the great user interface imagineer J. K. Rowling once said: "Predicting the future is a very difficult business indeed."

Sometimes innovations simply require the proper moment to take root. In 1965, Western Electric ran a magazine advert for a hybrid between a television set and a telephone. We now know, half a century later, such a product never took the world by storm. Yet all those years ago that team of Western Electric designers had hit upon an essential grain of truth: Eventually the television and the telephone would converge in the consumer marketplace. It just wouldn't happen until you could carry the technology in your pocket.

The details may not all be clear yet, but eventually we will be living in an eccescopic world, and we need to start designing for that world.

The game is already in the box.

Biography

Ken Perlin, a professor in the Department of Computer Science at NYU, is the director of the Games for Learning Institute, a member of NYU/MAGNET, and founding director of the Media Research Laboratory. He is a recipient of the SIGGRAPH Achievement Award and an Academy Award for Technical Achievement. His computer graphics work is featured in the Whitney Museum of American Art.