WELCOME TO THE HOLODECK

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For years a group of computer geeks, inventors, game theory mavens, engineers, music tech nerds, math whizzes, informaticians, and other digiterati across the NYU spectrum collaborated from time to time on various projects pegged to their mutual fascination with virtual reality (VR). What they dreamed of (but couldn't afford) was the chance to build a dazzling, futuristic supercomputing environment where all of their projects could interact and exponentially grow—something like the Holodecks on board *Star Trek* starships … but in the heart of New York City, not science-fiction outer space.

In late 2016, on their second try, this group won a $2.9 million grant from the National Science Foundation (NSF) to do just that. The university is contributing another $1.2 million to the project.

Fans of sci-fi probably remember that the Holodeck often functioned as a psychological Club Med for earthling crew members who were homesick for their culture. They would whoosh through the octagonal door to the Holosuite and, depending on the program they selected, could soon be tramping through the forests of their home planet, exploring the Wild West, playing on rival virtual baseball teams, or hanging out with Sherlock Holmes. These dreamscapes were said to use an advanced technology in which holographic people, places, and things seemed as solid as the actual physical world.

NYU doesn't have a Holosuite—it has three, all with normal doors. Two are in Manhattan, one at the Nursing Informatics Lab on First Avenue and the other at the Media Research Lab off Washington Square, and a third in Brooklyn at the Media and Games Network. The applications of the NYU Holodeck project are spread among four schools: the Courant Institute of Mathematical Sciences; the Rory Meyers College of Nursing; the Steinhardt School of Culture, Education, and Human Development; and the Tandon School of Engineering.

The NYU group has specialized in programs that let multiple users experience the Holodeck together in real time: think classes, conferences, and concerts rather than preprogrammed video games. "It's all about looking at the future of conversation," says Holodeck collaborator R. Luke DuBois, associate professor of integrated media technology at Tandon. "If you go back to those cheesy ads from the '80s—'Reach out and touch someone'—that's the premise of how to bring people together when they're in different places. If you're in San Diego and I'm in Brooklyn, can we draw something together, or perform music together, or explore a data set together if we're medical researchers?"

Despite its name, the NYU Holodeck isn't grounded in holography—no Hogwarts bathroom ghosts or Princess Leia "Help me, Obi-Wan Kenobi" messages, much less the full-immersion starship technology. Although the five-year project is only in its initial stages, the programs under way usually require participants to wear goggles or headsets.

The goal, says Jan Plass, professor of digital media and learning sciences at Steinhardt, is "playful learning." So, in other words, you might not be able to solve cases in an alternate universe with Holmes and Watson, but the educational stuff will still be entertaining. On the following pages are what some of the collaborators from the four schools have in mind for the future, separately and together.

COURANT INSTITUTE OF MATHEMATICAL SCIENCES

KEN PERLIN PROFESSOR OF COMPUTER SCIENCE

"It used to be that when I wanted to teach computer graphics, I needed to draw a matrix on the blackboard and then say, 'Imagine that this matrix could do something,'" says Perlin. Now a project called Chalktalk lets him draw a three-dimensional matrix that seems to hover in the air in front of his students. The matrix "comes to life and now they can see that there is the mathematical object and what it does," Perlin adds. "Anything you can calculate mathematically about a matrix and its rows and columns on paper—rotating it in space, assigning numeric values, adding a variable based on time—you can now do visually." (For a demonstration, Perlin suggests googling "Chalktalk in augmented reality.") "When you can actually show things, learning is accelerated," he says.

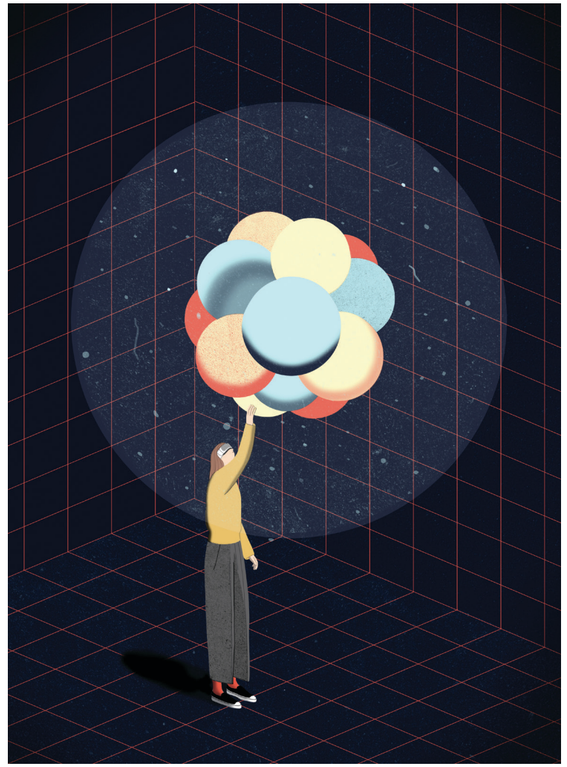
Perlin, who was given a Technical Achievement Award from the Academy of Motion Picture Arts and Sciences for a technique used in Hollywood computer graphics, is also the director of NYU's Future Reality Lab and Steinhardt's Games for Learning Institute. He and his fellow Holodeck collaborators refer to projects like Chalktalk and to certain technologies and machines as "tool kits"—elements that will be combined as the Holodeck's potential is unleashed.

One of their major research projects (also googleable) is Holojam, where participants can be part of a cartoon tableau. Perlin mounted a theater piece where both actors and audience members wore VR headsets that transformed them into magical creatures. In an *Alice in Wonderland*–inspired scene, the audience followed a rabbit and everyone shrunk down to become tiny.

It was by all accounts dazzling entertainment, but to Perlin it was also a scientific jumping-off point. The virtual ability to travel, say, inside a cell or an atom has enormous implications for fields including surgery and physics. But it also raises interesting mathematical questions for future Holodeck programming. "If we were smaller than a micron, we wouldn't be able to perceive light," Perlin explains, "but we still want to be able to see the atom, so we use a mathematical reconstruction of the atom based on our best knowledge of the mathematical properties of the atom and we create essentially what's partly a deliberate fantasy in which we can still see at that scale." Right now science can only speculate about how such hand-clapping-in-the-forest fudging will affect the observation of scientific principles. "Which is why you have to build these virtual reality–based shared experiences," Perlin says. "You have to build them, put scientists in them, and see whether they can use them as valid instruments."

On the NSF grant application, Perlin is quoted predicting that the NYU Holodeck could be as revolutionary as the particle physics laboratory at CERN in Switzerland, because it has the potential to "become the world center for a new type of science." But much of what the Holodeck can do won't be known until future researchers take its capabilities to the next level. By analogy, Perlin explains: "If you have a more powerful telescope, you can resolve fainter stars that are farther away in galaxies, and that means you can verify which of your theories about the big bang or the laws of physics are true, because you have more experimental data. [But] at some point we realized that much of the important information that physicists needed to verify or refute theories was outside the visible light spectrum. So they started building completely different kinds of telescopes, with radio frequencies."

NYU, Perlin concludes, is "building a better telescope."



RORY MEYERS COLLEGE OF NURSING

WINSLOW BURLESON ASSOCIATE PROFESSOR OF NURSING

Burleson, who is also an affiliate at four other schools—the Courant Institute of Mathematical Sciences; the College of Global Public Health; the Steinhardt School of Culture, Education, and Human Development; and the Tandon School of Engineering—is the principal investigator of NYU's Holodeck project and the writer of the winning NSF grant. He predicts that this technology will form what he calls "the classroom of the future."

He envisions such capabilities as medical students using VR to learn, for example, how to do injections into the spinal column, with more-realistic tactile feedback than can be gotten with cadavers. Nursing students similarly will be able to start moving beyond the two traditional practice objects: actors (with whom students can't develop real-life skills like looking at pupil dilation or adrenalin response) or manikins (which don't have the human facial expressions, eye contact, posture, gestures, and other interactions that are easy to build into virtual characters).

This potential rapport with VR "patients" holds promise for those with conditions such as Alzheimer's or autism. One current project, developed with the support of the Alzheimer's Association, uses interactive sound and visualization to help people with special needs take their clothes out of a dresser and put them on, step by step. "People living with dementia don't remember how to get dressed," Burleson explains, "and they often have conflict with their caregivers in this area, but they are able to follow instruction."

Burleson is tasked with overseeing the tech's synergy at NYU—the slicing, dicing, and cross-pollinating of his colleagues' projects. Steinhardt's Plass has created a game to help kids develop cognitive skills by "feeding" cartoon aliens—then rolling with the punches when the aliens change their food preferences. In addition to teaching hand-eye coordination, the game trains the brain to make fast choices. The Holodeck could, for instance, combine Plass's game with the motion-capture work of Tandon's DuBois (details on page 37), perhaps in a multiplayer setting, so that people who are recovering from a stroke could sharpen their cognitive and motor skills.

The Holodeck will eventually be opened up to proposals from outside institutions. The main rules will be that users leave something helpful in the instrument and that their data isn't a secret. Viewed as a construction set, every player should add on a few bricks and, ideally, some new ways to lay bricks, too.

It's precisely this idea that makes the NYU project unique, according to Burleson: "We aren't the first people to build a Holodeck-like environment, but we're the first ones to build it as a robust, sustainable platform that will support research agendas."

STEINHARDT SCHOOL OF CULTURE, EDUCATION, AND HUMAN DEVELOPMENT

AGNIESZKA ROGINSKA MUSIC ASSOCIATE PROFESSOR OF MUSIC AND MUSIC EDUCATION

Sound technology is a crucial component of virtual reality. "If you have a visual environment where you are inside a teapot, but it doesn't sound like you're inside a teapot, it's not convincing," Roginska notes. Moreover, the visuals and the sounds have to be synchronized—"not just what you hear, but how when you move, the sound has to follow you in a very specific way," she adds.

For instance, in the *Alice in Wonderland* theater piece, a graduate student Roginska advises, Marta Olko (STEINHARDT '20), designed soundscapes to accompany the magic realism visuals. When a virtual bird flew through the scene, it had to sound to all the participants' headsets the way a real bird flapping and cawing would sound at all the different locations in the room. When everyone in the room seemed to shrink in size, the sounds—the rain, the crickets, everything else—had to change, too.

The goal within the Holodeck is "to get to the point where you can't differentiate a real sound from a virtual sound . . . which is a challenging thing to do," says Roginska. Some advances will come externally, as headsets and other gear improve. Others will result from programmers figuring out (with software, recordings, and various algorithms) how best to re-create what Roginska calls each sound's "acoustic fingerprint"—a matter of where the sound happens as well as what it is. A person talking or playing an instrument inside a cathedral sounds different than the same sound in a park or in a living room, although much of this auditory knowledge happens at an instinctual level. "Our brains have evolved over thousands of years to pick apart information from the sound, because that gives us clues to where we are and if there is any danger coming," Roginska says. "When we go into the virtual environment, it's exactly the same thing."

The Holodeck holds out the promise of making any group whose dealings would be enhanced by face-to-face contact truly feel as if they are in the same, say, orchestra pit and to reap the benefits of that feeling of connectivity. Roginska's students are researching what happens when two musicians are playing in the same room versus when they're performing together in separate studios. "There are significant differences in the performance, the phrasing, the tempo, and other factors," Roginska reports. At this point no one knows exactly why togetherness encourages creativity, she adds, but "something magical happens when you are in the same space. On the Holodeck, what we want to do is create that space as much as possible and make it indistinguishable both in the sound but also in how people interact."

TANDON SCHOOL OF ENGINEERING

R. LUKE DuBOIS ASSOCIATE PROFESSOR OF INTEGRATED DIGITAL MEDIA

DuBois is drawn to the Holodeck's dual demand for intense data crunching and pure fun. "The stuff I'm interested in has some bits of very hard-core engineering," he says. "But I'm also an artist." DuBois is, in addition to his main appointment at Tandon, an associate professor of music and performing arts professions at Steinhardt and interactive telecommunications at the Tisch School of the Arts. "The Tandon side of the grant is one of the ones that works most around creative expression," DuBois says.

His students, who come from these three schools, tend to mingle and mash up: artists who want to work with technology, engineers who want to create art, and people with improbable degrees in, say, both engineering and dance. (Although, DuBois points out, that's a great combination for anyone who needs to choreograph very precise motion for an actor in a motion-capture suit.) Past DuBois–managed experiments have included everything from live human puppet shows to figuring out how to make an actor look and move like a statue while talking to an audience in the Metropolitan Museum of Art.

Beyond encouraging students to develop unusual skill sets, DuBois adds, the Holodeck "gives us a tool to connect clinical practitioners all over the world to look at the same visualizations. It's like a VR version of Google Docs, and that's really a sexy thing. I can also have a bunch of actors in Brooklyn in capture suits and you're in Manhattan looking at a rendering of their actions, so it looks like a 3-D cartoon, except that you can move among them and it's live and they know you're there, so they can come up and whisper in your ear. Stuff like that." The unsexy part, the hard-core engineering, "is about latency and data—how fast can I get you the smallest amount of information that will give you the most amount of communicative agency?" DuBois says. "It's about leveraging computers that are fast enough that they can render these beautiful worlds."

DuBois, who co-directs NYU's Ability Project—a multi-school lab focused on assistive technology and adaptive design research initiatives—is especially interested in the possibilities for healthcare. "Right now if you have a stroke, your therapy to regain your balance usually involves hundreds of thousands of dollars at your local research hospital," he says, "but I can replace it with an Xbox game that you can do at home with your grandkids."

DuBois's ultimate dream for the Holodeck? "We're going to show everybody how they can make their own," or at least a low-end version, he explains. "I want it to be in your neighborhood community art center, or your junior high, or the computer club at the community college." It's not unthinkable: built into the NSF grant is a commitment by the NYU group to publish all of its source code and other findings—a factor that ultimately will allow Holodeck technology to trickle down from the academic and scientific worlds to the average consumer. DuBois predicts that it will be like the phone: once a rare luxury, "like *Downton Abbey*, one rich person calling another rich person," but now an essential in everyone's pocket.