A CONCRETE INTERFACE

Creating an interface for virtual reality powered by wheelchair users

The Blended Reality Laboratory is an applied research hub for those exploring ideas that operate at the intersection of real and virtual worlds. Located at the Center for Collaborative Arts and Media (CCAM), the Blended Reality Laboratory draws upon CCAM's mission to connect the arts and sciences through experimental technology and collaborative research. The laboratory and its projects are underwritten through a hybrid structure of academic, industry, and applied research support.

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"No, the interface is not actually made of concrete," says Justin Berry, with a smile, in response to a question he has clearly been asked more than once. While the question might be one that he is tired of answering, it is hard not to ask, since the term 'concrete interface' is not a common one. Concrete, he later explains, doesn't refer to the building material; it refers to the kind of interface that he and fellow researchers are trying to design for the medium of virtual reality. "An abstract interface is one where you a push a button with an icon on it and something happens far away, but a concrete interface is one where, if you want to kick a soccer ball you need to, well, kick a soccer ball. You are not telling the computer what you want to happen, you are showing it."

Berry, the principal investigator for the Blended Reality Lab, likes to talk, and will do so at great length about these kinds of theoretical concepts, but it is his partners in the project that understand how powerful it can be to turn these kinds of theory into practice. Dr. Yetsa Tuakli-Wosrnu, founder of the Sports Equity Lab and faculty at both University of Pittsburgh and Yale, was already looking for ways to reduce the stigma that disabled athletes face when she met Berry. Dr. Tuakli, an athlete herself, was a long jumper for the Ghanian national track and field team, a team which she says was completely inclusive; she trained side-by-side with disabled athletes. "Sports are the great equalizer," she says. "The team gave me firsthand experience of what inclusion can accomplish. All those differences melted away instantaneously when we started practice."

She understands how effective it can be to create a way for abled and disabled athletes to compete with each other side by side, because she wants other athletes to recognize the intensity and physicality of their para-athletic peers. She imagines a site in the olympic village where the best athletes in the world can challenge each other, getting to know each other and building mutual respect in the process. In describing this idea to Berry, he realized that not only is it possible to build an experience like that in virtual reality, it might be one that is superior to the other models that dominate the field. "People think VR is a gaming medium, but it is more than that, while you might tell your character to jump in a game, in virtual reality you have to stick the landing." A proponent of Universal Design, Berry is excited to flip the script on the narrative around accessibility. What would happen if a wheelchair accessible interface was not an alternative, what if it is simply the best option available?

A manual wheelchair is, by itself, already a concrete interface, exactly the kind of thing Berry has been discussing with his students; when you want to roll forward, you grab the wheels and roll them forward.

Using a wheelchair to navigate virtual reality is not a new concept. Researchers at places like HERL, the Human Engineering Research Laboratories at University of Pittsburgh, have been doing it for decades. Experts there have tried dozens of variations, which is why Dr. Tuakli, forging a relationship with them, has brought their expertise to bear on the project. According to Berry "At first I was worried that we were re-inventing the wheel, but then I realized that while the wheel might have been around for a long time, it became something very different once there were lots of highways for it to roll on." While using a wheelchair to navigate VR is not new, the opportunities that exist to leverage such an interface have expanded exponentially. Virtual reality has gone from an elaborate and expensive set-up that costs thousands of dollars, and

requires a dedicated space, to something that costs a few hundred dollars, requires no set-up, and can fit into a backpack. Developing interactive virtual worlds has also gotten easier; while it used to require large teams and lots of capital, free platforms like Unity make it possible for individuals, with no budget, to develop novel experiences.

The 'Easy Roller,' an earlier prototype that inspired the current iteration of the interface (designed by students with direction and collaboration from Dr. Tuakli and Marjelle Scheffers) is about creating a low cost training platform for athletes in places where there are few options. "The soul and heart of the project is in sports with athletes in low-resource countries. An intersectional space," says Dr. Tuakli. "No one takes people in West Africa as a starting point for anything. Where and how something starts matters." This ethos, embedded in the project from the very beginning, means it is imperative that the system be as affordable as possible, as modular as possible, and as open source as possible.

Johannes Sieberer, a PhD candidate in the Mechanical Engineering department at Yale, laid the groundwork for the structure and the software that powers the interface. Hired as a Visiting Assistant in Research, he traveled from Austria to work full time on the project as part of his Master's Thesis. Originally intending to focus primarily on the physical design and fabrication, a serendipitous visit to the Advanced Prototyping Center at Yale's Wright Lab created new options. The Director of the Center, Dr. James Nikkel, was excited enough about the possibilities of the interface that he offered to support the design and fabrication with some of his own time.

Sieberer, with a new focus on the electrical design and software interface, created the tools to allow students like Brice Bai, an undergraduate student at Yale College, to practice building experiences to test the new interface. Bai, as part of her Computing in the Arts Thesis, built a playground that users could navigate in the wheelchair with the individual components referencing ADA compliant design. When trying to tune the system to minimize nausea, a common side effect in virtual reality, Johannes discovered that there were not enough studies showing the difference between walking and wheeling in virtual reality.

Reaching out to Dr. Veronica Weser, the Associate Director of XRPeds, an innovative research space at Yale focused on building new ways for virtual and augmented reality to support pediatric patients, he wondered what it might look like to quantify the qualitative difference between the comfort and intuitiveness of this seated VR interface against the current standard: 1:1 walking, in which one step in VR equals one step in the physical world. With a background researching the cause and impact of simulator sickness, Dr. Weser not only knew what it might look like to test the fundamental differences between walking and wheeling in VR, she knew of new and innovative tools, made available to the Blended Reality Lab by HP, that might offer insights never before available.

HP's Omnicept, a virtual reality headset embedded with a suite of biometric sensors, allows researchers to gather a wide range of data in real-time while users interact with virtual worlds. "The HP headset is a game changer because all of the sensors are embedded in the headset and they are totally integrated and you only need to plug in one wire and you can access your entire suite of data," says Dr. Weser.

Not only does the headset capture a wealth of data, it also provides a synthesis of that data in a metric called Cognitive Load. Cognitive Load looks at the way your body responds to an experience to provide feedback on how stressful or challenging the experience is. By working with the other researchers at the Blended Reality Lab, Sieberer and Weser designed an experiment with over 30 participants that navigated randomized mazes in virtual reality by both walking and wheeling. The results were exciting. “Research tells us the best experience in VR is always standing and walking. Our preliminary results tend to look in another direction,” says Sieberer.

The results, while still preliminary, show wheeled users having a reduced cognitive load when trying to remember where they entered a maze. Spatial updating tasks like this are important, because they are connected to the fundamental qualities that make virtual reality so unique, emphasizing the effect of presence and immersion.

Being able to completely replicate the experience of navigating a wheelchair through space is still a long way off, especially for a system that can handle the intensity para-athletes would bring to bear on it. At the same time, the path to that outcome is lined with an endless array of use cases that can improve lives today. Inspired by these possibilities, the leaders of XRPeds, Co-Directors Dr. Kimberly Hietfje and Dr. Asher Marks, are looking to carry the project forward with a focus on projects that will directly improve the lives of pediatric patients. Being able to simulate the experience of crossing a street in a wheelchair at a busy intersection means that patients in rural hospitals can practice navigating cities. For the same patients, struggling with the impact of a new injury, this might mean being able to spend time wheeling around their bedroom at home and getting comfortable with the layout, or even changing the layout, before having to do so without the care and support of the hospital staff. Interactive and immersive experiences can make rehabilitation and recovery something that does not feel clinical or boring and transform a necessary burden into a playful escape.

The Concrete Interface team at the Blended Reality Lab is not creating an experience, they are creating a set of expanded possibilities. By creating tools that are modular and open source and as affordable as possible, they are not only addressing the challenges that they are aware of but providing new forms of agency to those with the insight and experience to overcome obstacles they have yet to imagine.