Meet yourself, as you really are

Extended Reality and Embodiment in the Mirror World

augmented reality
embodiment
digital memory
avatars
extended reality

Reed, Matt[1]

[1]Freelance inter-media artist (www.mattreedartist.com), M.A. student in architectural and urban design. University of Brighton, UK. mattreed24@gmail.com

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My interest is in ‘extended reality’ (XR) technologies, particularly augmented reality (AR), and the worlds that they are creating. Worlds that transcend the border between the real and the virtual. This edition of the *UOU scientific journal* (Borders) is a useful moment for me to bring my thoughts together and to consolidate them into a ‘student’ essay submission for the journal. It tells a story and reflects upon my engagement with a module on my MA in Architectural and Urban Design degree. I hope it provokes others, likewise, to reflect upon the theme.

Note: The title “Meet yourself as you really are” comes from a 1936 psychology book of the same name by Prince Leopold Loewenstein and William Gerhard.

INTRODUCTION

We are standing at the beginning of a new era. Advances in artificial intelligence, deep learning, and spatial computing already significantly affect the way we live our lives. The media is filled with conjecture about the future of the so-called "metaverse," a virtual reality-based world (or, more likely, a decentralised network of worlds) that promises to allow us to escape our physical bodies and live in other, virtual environments. But for me, this version of our digital future is not the most interesting or relevant, as another type of digital domain is already being constructed. Led by Niantic, the company that created Pokémon Go, the entire physical world is gradually being mapped at 1:1 scale, akin to the fantastical map imagined by Lewis Carroll in *Sylvie and Bruno* (1889) or by the author Jorge Luis Borges in his 1946 short story *On Exactitude in Science*. Bit by bit, the world is being scanned in three dimensions to create a "mirror world" or "real world metaverse" that will enable augmented reality to be permanently fused in parallel with our physical plane of existence. These new virtual spaces, whatever form they take, will be inhabited by human users, or at least their digital representatives in the form of avatars. In these new digital environments, we will need 3D avatars that can interact with other users. These digital twins might look like our real bodies or allow us to take on any appearance we wish. Depending on the regulations that govern this new digital realm, whichever form we take could have far-reaching implications, with race and gender likely at the forefront of the debate. Our ability to build our bodies and identities digitally raises important questions about how to own and protect ourselves and how to keep our personal information safe in a digital world.

DIGITAL FOOTPRINTS

The term "Internet of Bodies" (IoB) describes how humans connect with computers and other electronic gadgets by means of their own bodies. Like the Internet of Things (IoT), this can take many forms, such as wearable devices that track and monitor different aspects of a person's health and physical activity, implants that provide medical benefits or enable new capabilities, and devices that allow people to control or interact with their surroundings in novel ways. No doubt, I am not alone in the fact that I would normally give little to no thought to the personal information being collected by my electronic gadgets. Wherever I go, my phone is with me, and everything I spend is monitored by my banking apps. My smartwatch keeps tabs on my heart rate and alerts me if it rises (or falls) beyond a certain level. My phone and watch are connected to a fitness app that records how active I am and sends that information to my health care provider, who then evaluates my progress and encourages me to do more by offering rewards. This element of gamification sometimes even motivates me to work out more. When used in conjunction with another app designed to improve mental health, it can make me feel more at peace and give me an increased sense of embodiment - a feeling of heightened awareness that I am part of a greater whole and not just living within my conscious mind. This is interesting because it echoes the thoughts of philosophers like Maurice Merleau-Ponty, who, in his embodied subjectivity theory, considered one's physical body to be a crucial component of the subjective self. I'm intrigued by the prospect of gaining a new perspective on the relationship between the body and the mind thanks to the virtual separation afforded by creating an avatar of myself and then observing it in the mirror world.

The record of my day-to-day travels kept by Google is both alarming and exciting. I have mixed feelings about privacy concerns and the prospect of advertisers buying and selling my personal information, and this is something I'll continue to ponder. The information that I'm accumulating will be permanently archived to serve as a more thorough record of my life than any scrapbook or diary could contain—a visual record that is far more comprehensive than any mere collection of holiday snaps. The sad thing is that very few individuals will ever see it, and the data will remain purely commercial. When I examine my online activities more closely, I find some noteworthy anomalies. For example, the iMax cinema in London is one of the locations on my list, but I have never actually visited it. This highlights a problem. Because the building is situated on a roundabout that I have driven around numerous times, Google assumes that I have been inside when in fact, I have not. As inconsequential as this error might seem, it nonetheless paints an incorrect picture of my actions and might have more serious ramifications given a different situation. This notion of digital memory and the possibilities it presents fascinate me.

It is said that certain people have what's called a "photographic memory", which is the capacity to recall a former scene in detail with amazing precision, exactly like a photograph. Could I somehow use augmented reality to leave a lasting impression within a particular space? Like a spectral, three-dimensional photograph, which begs the question: "Can a place have a memory of me?" An image of stone floors or stairs being worn down over many years by foot traffic instantly comes to mind. In the future, in the mirror-world, I might be able to show you my history by taking you to a certain location and rewinding time, presenting my past as a three-dimensional hologram. Could I somehow make a three-dimensional memento of a precise moment in time and then permanently fix it to that point in space? If so, what could these visual notes for future viewers be used for? To be able to find out, my next challenge would be to create a three-dimensional video avatar of myself and somehow place that memory into AR.

PRACTICAL EXPERIMENTS

The subsequent experiments were conducted with a spirit of playful curiosity, and while some

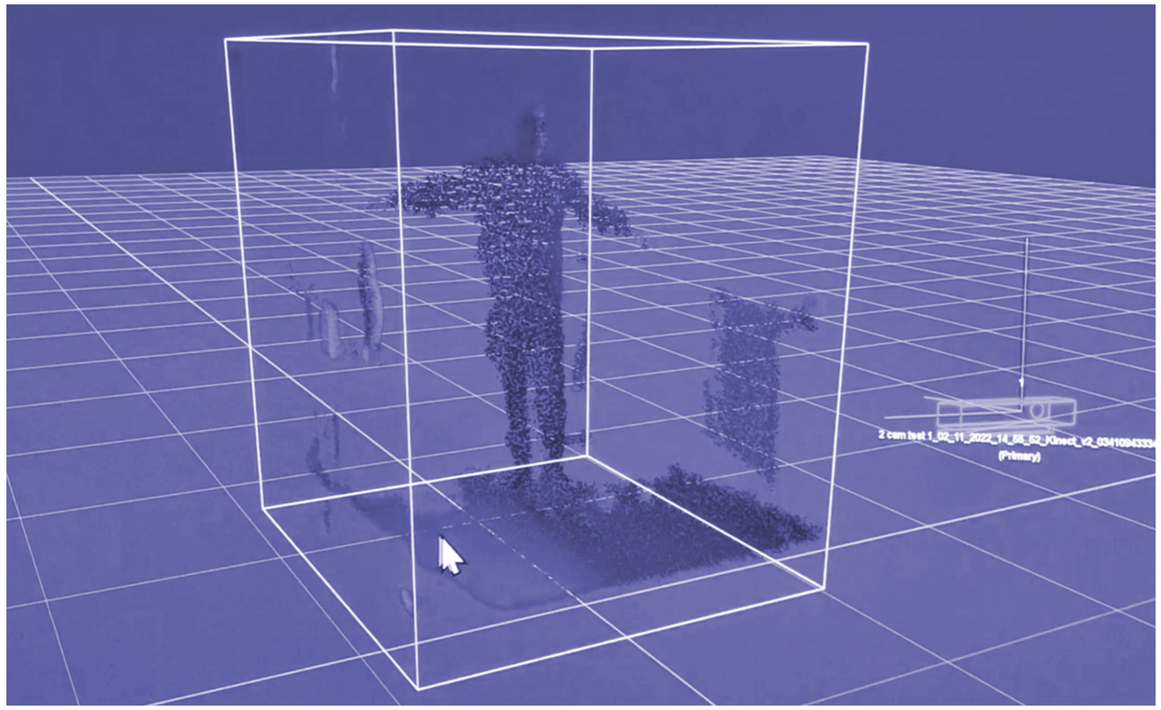

Fig.1 Video clip showing the volumetric point cloud generated by a single Kinect sensor camera.

of the work was undertaken with commercially available apps and scanners, the bulk of my time was spent working with repurposed Kinect sensor cameras, originally designed for use with the Xbox games console but now discontinued. When combined with the right software, these sensors can create volumetric video, a special kind of video that records and displays three-dimensional objects and spaces in a way that permits viewing from any vantage point. Professional setups with dozens of fixed cameras mounted from every possible angle, such as those used in the film and gaming industries, can be hired but are prohibitively expensive. But for less than fifty pounds, you can purchase a piece of equipment that will accomplish similar results. The cameras produce *point clouds*—three-dimensional models consisting of millions of distinct measurement points, each of which has an x, y, and z coordinate. Thirty of these point clouds are recorded every second to create the motion of the volumetric video (Fig.1).

(Click play button to watch video or go to https://youtu.be/W8yDkTSrHS0)

Previously, I have had varying degrees of success with these cameras due to their temperamental nature. Because of the sheer amount of data being processed, a very powerful computer is required, something I learned the hard way before purchasing a high-end gaming machine.

Most importantly, as I was only using one camera, I could only create a point cloud of one side of my body. To remedy this and create a 360-degree avatar that I could walk around in augmented reality, I would require multiple cameras. But, as the software I was using only supported one camera per machine, each camera would require its own computer, and these computers would need to be networked. In addition to this, the feeds from each camera view needed to be synchronised so that they could be aligned to create the complete 360-degree view. To my frustration, despite numerous attempts and even after contacting the online forum for help, I was unable to successfully align the cameras. I was able to get two separate cameras running on two computers to capture me from two perspectives, but I was unsuccessful in synchronising and then aligning the resulting point clouds. Although disappointing, in retrospect, this lack of success taught me some valuable lessons. More than a lesson in patience, I learned that it is okay to not know how to do everything and that my standpoint as an artist differs from, say, a computer science student. I also didn't have the luxury of time because the module's deadline was approaching, so I was forced to shift my focus to other things, which exposed me to new ways of thinking that I might not have considered if I had been successful in other areas. I was conscious that I might need outside help with the technical aspects of getting my volumetric video into AR. I reached out to Alex Judd of MAVRiC Research, who very kindly offered to develop an app in Unity that could display my volumetric video in AR. I gave him the two separate camera views that I had captured but had not aligned,

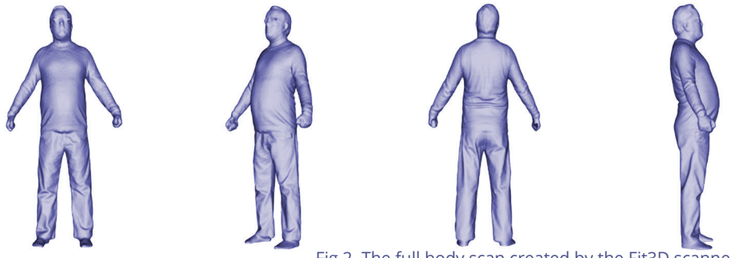

Fig.2. The full body scan created by the Fit3D scanner.

and I continued to research other ways to capture my image.

After some research, I found that a local health and beauty clinic has a Fit3D body scanning machine, and I paid to have my body scanned (Fig.2). The machines use a rotating turntable to scan the body in forty seconds, and from over 1000 images of the body, it calculates a variety of personal biometric data, such as weight, full body measurements, body fat percentage, posture, and how your body weight is distributed. As well as a 3D model in the form of an *.OBJ* file, I was given a detailed report on my biometrics, which are usually used to help people track their progress as part of a health and fitness plan.

This was by far the most accurate method for creating a digital representation of my body, although for the purposes of this research, physical accuracy is not necessarily what I am after. A disadvantage of this model compared to the volumetric video is that the avatar is static. However, until I can make the volumetric video version work in AR, this appeared to be a great option for an asset that I could try with third-party apps due to its comparatively small file size. Now that I had the file from the scan, I was able to have 3D printed models of my body created, providing me with an additional, more analogue representation of my body that I could position in physical space (Fig.3). Made to be 1:10 and 1:25 scale, these models could be incorporated into physical architectural models, and even though these models are not digital, they still elicit thoughts about embodiment and body image. This new perspective takes some getting used to, but I will always have this three-dimensional snapshot of how I appeared at precisely 10:17 a.m. on December 7, 2022.

Throughout this time, I had been looking at commercially available apps that could capture my image or take an existing 3D model and insert it into augmented reality. There are several options available online, with new ones emerging all the time, and I prioritised those that were either free or offered a free trial. I will not discuss all the apps I tried in this essay, but I will say that the results were mixed. The majority required me to download and install an app onto my phone, but recent developments have led to WebAR becoming much more popular. WebAR is a relatively new technology that can function without a mobile application. Using the smartphone's built-in camera and mobile web browser, users can directly access AR experiences. One of the primary reasons for WebAR's popularity is that it is so simple to use, meaning that people are much more likely to participate; however, there are disadvantages. WebAR is dependent on an internet connection, which necessitates smaller file sizes. As a result, older phones may have difficulty running WebAR applications smoothly. The difficulty in my case was that volumetric video tends to have very large file sizes, so it would not be possible to use a WebAR application, but Alex Judd of MAVRiC Research assured me that he could develop a standalone app in Unity that would work.

Fig.3. 3D printed models at 1:10 and 1:25 scale.

In the meantime, I had managed to get my Fit3D scan into WorldCast Studio, a browser-based tool for creating WebAR experiences. The beauty of Web AR is that it requires no coding and is quick and relatively simple to create.

Fig.4 below is a QR code that will activate the experience, allowing you to try it out for yourself, and you should be able to see my avatar within your space. I refined the model in Blender and changed its colour from the rather dull greyish white, and I also increased the transparency to 70 percent to create a more ethereal effect. The model was then raised 50 cm above the ground, and a slow rotation was added. The WorldCast Studio platform also allows sound to be added so I recorded a short piece of audio of my voice to increase my sense of presence.

Fig.4. Scan this QR code with a mobile device to activate the AR.

Another exciting function within WorldCast Studio is the ability to create location-based AR, meaning that an asset can be remotely placed at a point anywhere in the world. It accomplishes this by allowing you to attach the model to a GPS location on a map so that the model will appear when you move to within five metres of the anchor point at that place. I tested this by fixing my model to a nearby park (Fig.5) and experimented with changing my scale.

Playing with the proportions of my body and imagining myself as a giant was entertaining, but the experience inspired me to take the idea further. As part of the "My Virtual Vacation" art project, I've had my virtual self stand in for me on five continents: West Sussex (UK), Goa (India), Dar es Salaam (Tanzania), Los Angeles (USA), and the plaza in front of the Sydney Opera House (Australia). Due to my project deadline, I had to cut my trips short there, but if you'd like to contribute to the ongoing artwork, please feel free to email me a screenshot of my avatar in your environment to the address at the top of this paper. And please, feel free to have fun with it.

Fig.5. My giant avatar placed into a local park using World Cast Studio.

Inadvertently, the people I know all over the world have started constructing an entirely new digital map of my travels. This map is analogous to the one that Google generates from the data on my phone, with the exception that this time every memory of a place I've been is a fabrication, at least in the physical sense (Fig.6).

This was a lot of fun for me as well as for my friends, who all remarked on how it seemed as though in some way I was there with them (Fig.7). I'm sure that, at some point in the future, we will be able to conduct virtual meetings with other people from across the world, where we will chat with one another as 3D avatars, something already being worked towards by companies including Microsoft.

At the same time, Alex Judd of MAVRiC Research was hard at work creating an app for my volumetric video; I was able to download the beta version on my mobile device and test out the augmented reality experience. Although I had provided him with footage from both cameras, he was unable to edit them together in the time allotted. We attribute this to the lack of a concrete sync point to which they can be adjusted. In the future, I want to utilise a clapper board to provide a common reference

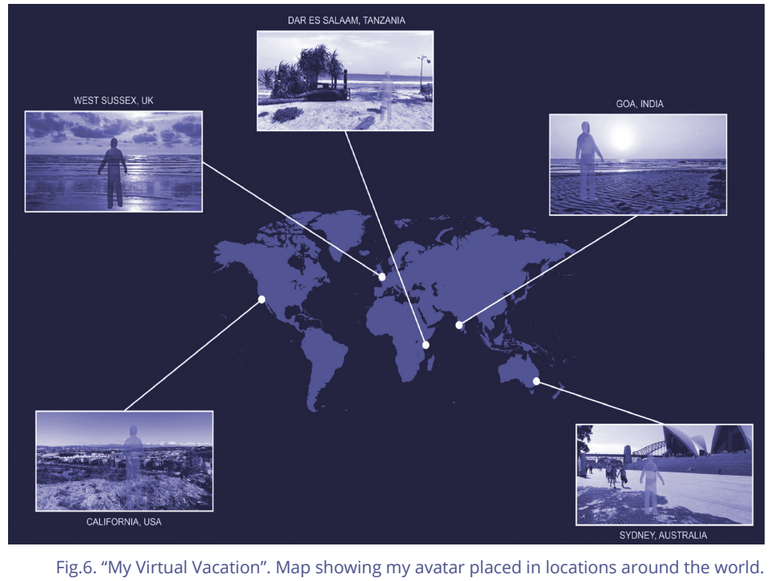

Fig.6. "My Virtual Vacation". Map showing my avatar placed in locations around the world. These images are screenshots from mobile phones and have not been created in Photoshop.

Fig.7. A friend in Goa, India having fun with the scale of my avatar.

frame that both sets of point clouds may use to stay in sync with one another. Yet, the findings were quite promising. I was able to see a moving version of myself for the first time thanks to augmented reality, and it was an unsettling experience. My hologram wasn't

Fig.8. Meet Yourself as You Really Are (2023).

fully formed as it was from just one camera angle, but I was still able to move around it and even through it.

The next stage was to ground myself in reality, so I shot footage of myself in a variety of different settings. But none of them were enough to fulfil my need to finally meet myself or to bridge the threshold between the real and the virtual. The clip below (Fig.8) is my first effort at making a video that attempts this. On the left, you can see my volumetric avatar that the Unity app places in AR. Then, on the right, you have the actual me—both of us there, in the same space, but existing in distinct realities and timelines.

(To watch video go to https://youtu.be/euOp2k__ShU)

CONCLUSIONS

With these preliminary experiments, I have begun to understand that AR provides a novel approach to enhancing the sensory experience of the human body and so fostering greater embodiment. It has been a lot of fun experimenting with different new techniques for recording and displaying my own image, and I now feel that I have a greater understanding of this field overall. It is my opinion that augmented reality is going to become significantly more widespread in the not-too-distant future and it will take us across new borders. In addition, I believe that many of us will begin to make use of avatars when the metaverse, in whatever form it takes, becomes a more significant part of our everyday lives. My intention is to keep working towards the goal of making a fully immersive 360-degree volumetric avatar, thus, my next technological challenge will be to persist in synchronising three separate sensor cameras. As I continue to explore, I might like to try out forming groups of holograms using multiple avatars, filming them from different angles to see how embodiment is felt within a crowd.

There are some answers to the questions I asked at the start of this project, but this is just the start of a much longer investigation. That said, I will strive to respond as best I can. Firstly:

"How is technology, in particular augmented reality, able to extend our sense of personal embodiment?"

The successes I have had with using different applications to capture my body image in 3D have allowed me to experience myself like never before. Like many people, I am not generally very comfortable with my own self-image and shy away from seeing photographs of myself. I have also never liked the sound of my own recorded voice, so having the chance to "meet myself as I really am" has been a fascinating experience. Instead of avoiding my own image, I have felt compelled to meet it and, at times, have found myself sucked in, observing my own image for lengthy periods of time. The fresh viewpoints that are shown to me intrigue me. I am literally able to look over my own shoulder and this gives me a strong awareness of the way others may perceive me.

Meeting my digital twin in the Unity app was the most unusual and thought-provoking of all the experiments, and that was the moment that really felt as if I was successfully bridging the physical and digital realms. I will work more to refine this and see where that takes me, but as far as gaining insight into what it feels like to experience myself in the digital world, this was the most powerful.

The World Cast Studio app was also very successful in making me feel a sense of my extended embodiment because, being run with web AR, it is very quick to trigger, easy to control, and easy to share with others. The added bonus of sound gave it an extra layer of me "meeting myself." This enhanced my sense of immersion and presence in the digital environment, making it feel more like an extension of my own body and senses. I also very much enjoyed interacting with friends around the world and placing my digital memory into five continents. This social factor demonstrates how, in the context of the metaverse, avatars can be a powerful tool for increasing embodiment and communicating with others in the form of their own avatars.

The word "embodiment" is used a great deal, but I really want to try to establish the meaning that is best for me to describe how this all makes me feel. It has different meanings in philosophy, psychology, and sociology and is often associated with the idea of the embodied self as presented in phenomenology and the work of Husserl and Merleau-Ponty, where the body is seen as being central to our identity, inseparable from sensory experience and perception. My experiments have allowed me to see an alternative view of myself from the outside, but they have also given me an insight into how technology is becoming a way for us to gain a greater understanding of how our bodies are working on the inside.

The biometric data being collected by our technology is helping us make new connections between the body and the mind, and technology is helping us to, in some ways, be better versions of ourselves. This starts to answer my second question:

"Can a physical space that I once inhabited have a memory of me, and how does memory play a role with new technologies like augmented reality?"

Fig.9. Memory QR behind wallpaper.

I've demonstrated that a 3D snapshot of myself at a certain point in time can be captured and then projected into a different place and time, both locally and around the world. These memories of ourselves could play a variety of roles in the future; perhaps digital memorials with avatars of lost loved ones using AI-constructed voices that can speak beyond the grave?

Another idea that occurs to me for how a place could have a memory is illustrated in Figure 9. In redecorating a new home and removing the old wallpaper, I am certain that some readers have discovered a child's artwork or a message from the former residents scrawled on the wall. What if, when you peeled back the old paper, you discovered a QR code stencilled on the wall behind? And, when this code was scanned, holograms of the family who had inhabited the place emerged, like a three-dimensional cine film of events from their lives, as though they were friendly ghosts of the past eternally present in that space.

I am aware of my own limitations when it comes to computers and technology, particularly when entering the realm of coding, so collaborating with Alex Judd of MAVRiC Research has been invaluable in enabling me to experience a moving point cloud avatar of myself in the mirror world, and I am very thankful to him for that.

To progress with this inquiry into the sense of embodiment felt by seeing one's own body in the form of a digital avatar and subsequently placing it into AR, it might also be useful to undertake a comprehensive phenomenological study to take the findings from this project further than my own personal experience. By performing a survey of a wider range of people, I would hope to gain insights into their reactions to their bodies being digitised and placed into the mirror world. The data collected from these surveys might clarify the relationships between lived experiences and the theories used to explain those experiences, with an emphasis given to post-phenomenology, an area that focuses specifically on understanding the roles that technologies play in the human experience.