Holojam in Wonderland: Immersive Mixed Reality Theater

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ABSTRACT

Holojam in Wonderland is a prototype of a new type of performance activity, "Immersive Mixed Reality Theater" (IMRT). With unique and novel properties possessed by neither cinema nor traditional theater, IMRT promises exciting new expressive possibilities for multi-user, participatory, immersive digital narratives. The authors describe the piece, the technology used to create it and some of the key aesthetic choices and takeaways.

Virtual, augmented and mixed reality provide a new toolbox for creating a broad range of experiences, including new forms of expressive works. Many artists are exploring the potential of virtual reality (VR) as a narrative medium and for its ability to foster deeper engagement with characters and stories. Narrative VR has much in common with theater, using the three-dimensional space around the viewer and multiple sensory modes to tell the story. What has been missing until recently is the ability to share the experience with others in real time. By investigating the affordances of virtual reality for multi-user, live, immersive performance, we have developed the concept of a new type of performance activity, which we call "Immersive Mixed Reality Theater" (IMRT). To explore the aesthetics of IMRT we created a seven-minute piece, *Holojam in Wonderland*, inspired by *Alice in Wonderland*, in which two performers and four audience members share a magical journey to Wonderland and back.

Background

The term "mixed reality" (MR) was coined to refer to a "subclass of VR related technologies that involve the merging of real and virtual worlds" [1]. Microsoft proposes that MR spans the entire spectrum from physical reality to "digital reality," placing VR at the "immersive" end of that spectrum [2]. IMRT combines 3D, 6DOF VR imagery with real people and objects physically present in the space around the viewer. Thus, a participant may see a virtual table which is also physically present and touchable. Similarly, they will see another person as an animated avatar in the virtual world and both hear their real voice and sense their actual touch. The result is an immersive sensory experience combining virtual imagery with physical presence.

This approach allows us to intermingle live performers with the audience. There have been other narrative productions which do this with only one performer and audience member, such as *Draw Me Close* (National Theater of Great Britain and the National Film Board of Canada, 2017) and *Jack: Part One* (Mathias Chelebourg and Baobab Studios, 2018), and there are game-like experiences where multiple players can navigate a VR space together and participate in an interactive adventure (cf. productions by The Void). In contrast to these, our goal was to create a narrative piece with multiple performers and audiences, expanding the kinds of stories that can be told and the number of people that can experience them simultaneously. The present limitations on scale are the size of the area in which participants can be tracked and the bandwidth required for transmitting tracking data: both restrictions that will relax as the technology evolves.

IMRT is a form of immersive theater in which the audience experience is central to the work [3]. The current popularity of participatory immersive performance pieces like PunchDrunk's *Sleep No More* (2011) coincides with easier access to virtual reality technologies, the generalization of digital games as an entertainment activity and the growth of escape room activities, all resulting in audiences being more accustomed to the idea of becoming participants in the stories that are told to them.

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The use of virtual reality technology enables us to do things that cannot be done in physical theatrical spaces. Our project explores the new affordances provided by this technology to enhance the capabilities of theatrical storytellers and pushes on content and technology simultaneously. Although this is a difficult challenge, we believe it is the most effective way to advance a new artistic medium.

Content and User Experience

Holojam in Wonderland is a linear narrative with clearly defined story beats, and audience interaction does not influence how the story progresses. But the audience members are not mere spectators: they are given roles in the story world as Alice's friends. Alice addresses the audience directly, sharing her emotional state with them and inciting them to participate at various points. Alice is both a virtual avatar and a living actor right there beside them (Fig. 1). The performance is a live interaction between real people, and the actress can improvise based on how the audience responds.

At the start of the show, the audience enters a black box performance space containing a few set pieces suggestive of a Victorian drawing room. As they put on their headsets, they find themselves in a fully realized version of the room, with virtual representations of the real-world set pieces in the same locations.

Audience members are represented by avatars of butterflies in the virtual space; their position in the virtual room corresponds to their position in the theater. When the actor playing Alice dons a headset and controllers and begins speaking, the audience sees her avatar appear in the virtual space and she begins walking among them.

Alice adopts the audience as playmates and carries them to a forest glade where the rules of physics don't quite apply. They encounter the White Rabbit (another actor), and are magically shrunk to a tiny

Fig. 1. Actors Lulu Ward and Brian Alford perform as an audience member looks on. Behind is the minimalist physical set; these pieces were represented in the same positions in the VR world, while the rest of the room was filled in around them. (Production © NYU Future Reality Lab, 2017. Photo: © Juan Pablo Sarmiento, 2017. Props curated by Carol Silverman.)

size where mushrooms tower over them and a songbird threatens to eat them (Fig. 2). Alice enlists the audience to attract the now-huge Rabbit's attention as his voice booms overhead. The Rabbit restores everyone to their normal size and returns them to the drawing room where they began. Docents then help the audience out of their headsets and escort them out of the performance space.

The Technology

Multi-user, co-located VR experiences require accurate spatial tracking of all participants: everyone must be represented in the correct location in the VR world so people don't collide. We accomplished this using the Holojam platform [4], a software stack designed to integrate data from a motion tracking system into a multi-user VR application built in Unity. Holojam supports various VR headsets and motion capture systems, including OptiTrack (multiple IR cameras) and the HTC Vive trackers and base stations. The guiding principle has been to combine the features of current hardware platforms to prototype the kinds of experiences and interactions we will want to build using future technology.

Another principle of the Holojam project has been to develop a system that is cost-effective, using consumer grade hardware, so that this type of experience can be accessible to a wider range of artists and technologists. For this piece, we used the Samsung Gear VR headset, combined with HTC Vive trackers and controllers. One tracker was attached to each Gear VR HMD, to provide accurate positioning in space. The performers each held two controllers and wore a tracker at their waist and on each foot, allowing them to control fully expressive full-body avatars.

Holojam shares the tracking data for all the players plus shared virtual objects through a local wifi network. The software also performs sensor fusion between the Gear VR's IMU and the position and orientation data for the Vive Tracker attached to the HMD, to provide very accurate and responsive room-scale tracking for the players (Fig. 3).

The VR experience was built in the Unity game engine. Our technical director also built a means for live show control, running a version of the project on a desktop computer and using keyboard input to send show cues to the Unity game clients on the HMDs.

Fig. 2. A magical transformation as Alice and the audience shrink. (Scenic and character design: © Kris Layng, 2017)

Design Process

VR still has a strong novelty appeal, which helps attract an audience, but that is not a sufficient reason to use it to tell a story. We sought to demonstrate not just how to use VR for a theatrical experience, but why to do so. What sorts of stories would benefit from being told in virtual reality?

The visual fluency that CGI has brought to film has not been available to the theatrical creator, except through projections. VR can leverage the complete 3D CG toolset, making it particularly useful for telling stories that involve elements of magic or fantasy. Because the experiences are immersive, we can fully transport the audience to fantastical worlds.

Janet Murray describes transformation as one of the key pleasures of digital environments [5]. The flexibility imparted by CG allows us to take audiences from one place to another in any number of magical ways. Another effect that we have observed to be particularly powerful in VR is the ability to manipulate scale. Because there is no external frame of reference, we can make the user feel like a giant, or make them feel tiny relative to giant characters.

Given these affordances, *Alice in Wonderland* presents a natural story to start with: we could transport the audience to Wonderland and allow them to experience Alice's changes in size alongside her. Being well known, it helps bring the audience into the story quickly and efficiently; the name alone gives the audience sufficient context to follow along.

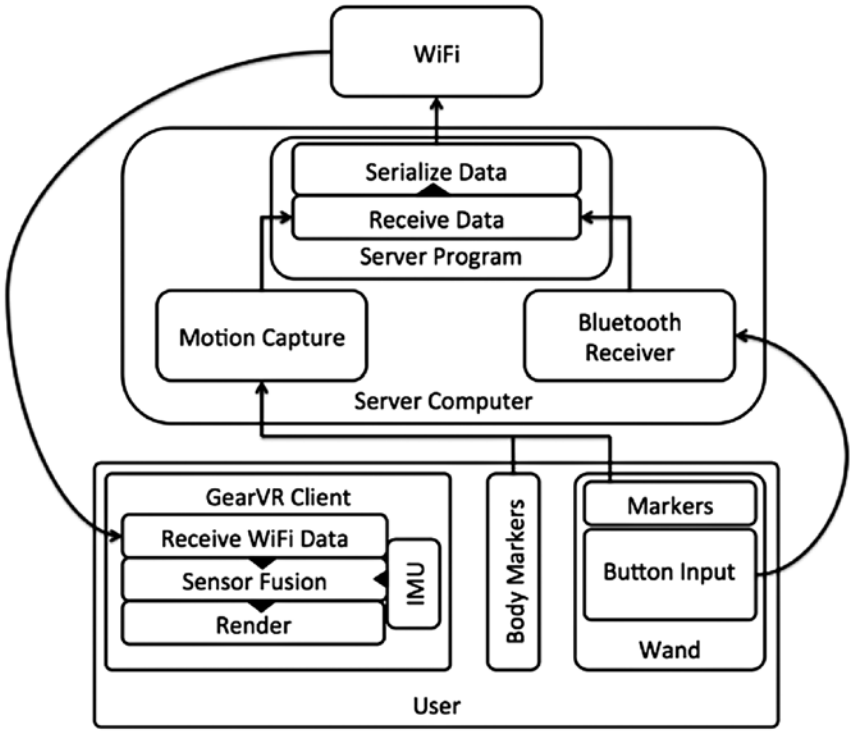

Fig. 3. Diagram of the Holojam system. (© Connor DeFanti, 2017)

Character Design

Performance in this medium is a form of puppetry. In our first iteration, the characters were only represented by a head and two hands. Because these moved in perfect synchrony with the actors' heads and hands, they felt alive and expressive (Fig. 4). In our final piece we used full body avatars, which gave more of a sense of the characters and better visual integration into the world, but did not necessarily convey a greater sense of aliveness (Fig. 5). This corresponds to observations of various styles of puppetry, as well as to recent research in avatar representations and presence in VR [6].

For the audience, butterfly avatars accomplished several goals. Aesthetically, the audience avatars should fit the world of the play and be similar to each other but clearly different from the characters to avoid distraction. Logistically, they also had to make sense without full body tracking and take up enough space around each audience member to avoid collisions in the theater.

Early audiences responded positively to their avatars not having any hands: it made it clear to them that they were not expected to do anything besides watch. Since Alice spoke to them directly, the primary mode of interaction would remain speaking with the characters. The audience avatar design helped focus attention on these key elements of the experience.

Sound Design

To support the story with sound and music we used a 5-speaker surround setup, with a speaker at each corner of the space and one hung from the ceiling. This allowed our sound designer to situate effects in space, including a bird chirping or a large rabbit looming overhead, corresponding with the visuals the audience saw. Subtle sonic effects were used to underscore moments of transformation during the piece and to emphasize the scale differences. The actors' voices were carried through the air, with no mediation. This reinforced that the actors were physically present with the audience.

Observations on Audience Engagement

The design team and authors observed approximately 150 participants through the course of a three-day run, and spoke to many of them after each session. As such, these observations were informal and unstructured.

During performances, the directions of audience members' gaze was informative. The audience was largely in sync during big movements like Alice or Rabbit entering the scene, or a bird flying overhead, especially when accompanied by a sound cue. At other moments, individuals were not united: during big, unpredictable changes or emotionally threatening scenes, they would follow their own interests in the environment, scanning the scene and looking quickly around them. This suggests that they were following the development of the story and responding to the dramatic events.

When Alice entered the scene, audience members usually oriented to her, responding to her questions, comments and requests. Alice had "power" over the audience members and they quickly learned to follow her lead. We did not observe any audience members taking on a disruptive action or contradicting Alice.

The audience clearly understood the rules of the world. For example, audience members watched Rabbit drink from a flask and shrink in order to fit through a tiny door. When Alice wanted to follow him and sought advice from the audience, most suggested that she drink from the flask as well, demonstrating that they understood the magical properties of the drink. Similarly, when it came time to grow back to normal size, audiences suggested Alice should eat the other edible item in the environment (a cupcake), transferring their knowledge about the world to achieve a new end.

Fig. 4. First iteration of character avatars had only head and hands, but with accurate tracking still felt alive and present. (Scenic and character design: © Kris Layng, 2017)

Like any experimental platform, *Holojam in Wonderland* experienced some technical difficulties. These moments illustrated an unexpected advantage of using live performers: they could smooth over the glitches, keeping the audience engaged. Users were usually the last to know something wasn't right.

Audience feedback was overwhelmingly positive, commonly describing the experience as "magical" and expressing the sensation of having been on a journey. This response suggests that IMRT is a viable medium for creating satisfying, collectively enjoyed, narrative entertainment.

Fig. 5. The White Rabbit in the final piece, more fully a part of the world. (Scenic and character design: © Kris Layng, 2017)

Conclusion

Holojam in Wonderland demonstrates a new type of experience: immersive mixed reality theater. Unlike theater or cinema, IMRT allows audiences to share an experience in a virtual environment with nearly unlimited possibilities for visual and sound effects. As source material, *Alice in Wonderland* offers narrative-driven opportunities to use the affordances of IMRT to full effect: changing the scale of the environment, staging a scene for multiple perspectives, and sharing this in real time. The opportunity for creators to build new experiences with these tools is exciting, and future work could explore additional interactivity as well as the creation of longer, more sophisticated pieces on a larger scale.

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