VR Viewfinder: The Effects of Enabling Third-person Perspectives for Bystanders on VR-based Interactive Media

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Abstract  
Virtual reality (VR) is an emerging technology of artistic expression that enables live, immersive aesthetics for interactive media. However, VR-based interactive media are often consumed in a solitary set-up and cannot be shared in social settings. Having a VR-headset for every bystander and synchronizing headsets can be costly and cumbersome. In practice, a secondary screen is provided to bystanders and shows what the VR user is seeing. However, the bystanders cannot have a holistic view this way. To engage the bystanders in the VR-based interactive media, we propose a technique with which the bystanders can see the VR headset user and their experience from a third person perspective. We have developed a physical apparatus for the bystanders to see the VR environment through a tablet screen. We use the motion tracking system to create a virtual camera in VR and map the apparatus’ physical location to the location of the virtual camera. The bystanders can use the apparatus like a camera viewfinder to freely move and see the virtual world through and control their viewpoint as active spectators. We hypothesize that this form of third person view will improve the bystanders’ engagement and immersiveness. Also, we anticipate that the audience members’ control over their POV will enhance their agency in their viewing experience. We plan to test our hypotheses through user studies to confirm if our approach improves the bystanders’ experience.
Author Keywords
Virtual Reality; Point of View; Interactive Media; Handheld Device; Virtual Environment

CCS Concepts
• Human-centered computing → Collaborative and social computing systems and tools; Interactive systems and tools; Ubiquitous and mobile computing systems and tools;

Introduction
Virtual Reality (VR) has been shown to be beneficial in many fields; specifically, VR has been used as an artistic medium [1]. However, sharing VR creations and experiences in a social setting (i.e., exhibitions, public demos) becomes an important concern. Bystanders - people in the physical reality - will neither be able to partake nor understand what a VR user is experiencing. Providing a VR-headset for every bystander has various issues, like high cost financially, computationally, and logistically. In practice, either projection or a computer monitor is used for bystanders to show what the VR user is seeing at the moment, so called first-person point of view approach (POV). However, the lack of agency and controllability of POV for bystanders makes it challenging to understand what is happening in virtual reality. In addition, POV on a secondary display is often limited for peripheral visions, making the 2D screen viewers have a less immersive experience [4]. Furthermore, a first-person perspective may cause motion sickness.

Therefore, we need a way of providing independent view methods for bystanders that allows them to interact and engage with the virtual world.

Figure 1: Illustration of VR Viewfinder concept

To address these concerns, we developed a physical apparatus for bystanders to see the VR-based interactive media. Using a motion tracking system, we anchored the locations of virtual cameras in the VR scene to the physical location of a physical apparatus, in the form of a tracked tablet. The bystanders can use the apparatus like a camera viewfinder to freely move and see the virtual world through the device screen. Also, they can control their own viewpoint as active spectators instead of passive onlookers, shown in Figure 1. Allowing the bystanders to interact with what they are viewing has been a way to engage them in interactive arts [12, 9]. Our goal is to allow bystanders to control their VR perspectives in their physical context, and thus, they could feel more immersed in the space.

We hypothesize that providing controllable independent views to bystanders will improve engagement and immersiveness when interacting with a virtual environment and a VR user. Throughout the entirety of the project, we will address the following research questions:

• How independence over point of view may affect engagement of VR for VR bystanding viewers?
• What interactions and behaviors emerge from independent bystander view?
• How does control over their virtual view influence bystanders’ situation awareness?

Related Works
Point of Views in VR
First person view in a headset may feel more realistic compared to a singular 2D display on screen due to head mounted displays targeting both eyes [14]. However, many have tried to offer a more comprehensive perspective by altering what
is shown in the headset. For example, Dunn et al. provided a single element optics that was capable of a wide field of view through the usage of a thin membrane [5]. This research shows the benefits of having such a wider outlook. An early VR paper by Fukatsu et al. presented a way of presenting a bird's eye view of a virtual world that is semi-controlled through the VR user's handheld controller, and it stated this view was more holistic [7].

**Situation Awareness in Immersive Media**

View independence is not only useful in VR. Tait and Billinghurst explored using view independence in AR for remote viewing [15]. Our windowed approach may be applied to augmented reality or mixed reality as well. Currently, we already know that the Vive headset is capable of using the front facing camera to simulate the physical world around the VR user, creating a mixed reality experience [6]. We could use this feature to determine whether it would help the VR user be more aware of bystander movements.

Another means of tackling situation awareness is through motion tracking. In a way, this is a simulated version of augmented reality, and may have similar situation awareness improvements that AR information exchange has [11]. We could place virtual indicators, or use avatars, to indicate members in the experimental space. This added embodiment may increase collaborative success as well in a shared virtual space [13].

**VR Viewfinder Design**

We have implemented a physically tracked tablet to display the virtual location of a bystander according to their physical location in space. This will work alongside a VR user who can draw and engage with a virtual environment while wearing a traditional VR headset. We used Unity and SteamVR to create this project. For hardware, we are using HTC Vive and the Vive tracker. Because our original goal was to create this project for live art performances, our current software allows the user to draw and move the camera rig around a very large virtual environment.

For our physical apparatus and camera control, we always knew that we wanted to be able to track the physical location and rotation, but it went through several design changes as well. Initially, we wanted to use an enclosed cave approach where the walls are screens that displayed parts of the virtual world depending on where the tracker is in the physical world in relation to the VR user [3].

For initial iterations we planned to use smaller displays to demonstrate our concept. However, the smaller displays offered us the idea to pursue a window into the virtual world approach. In order to make the “window into another world” feel more realistic, we manipulated the focus and lens of the virtual camera through software to make the view seem to be what the bystander would see from their eyes looking through the tablet.

**Validation Plan: Experiment Scheme**

We want to test various viewing conditions to determine the advantages and disadvantages of each for our research criteria.

1. First person POV by the VR user will be displayed for the bystander on a stationary 2D screen. The bystander has no direct control over what they see.

2. Third person POV that is anchored to follow the VR user’s general area of motions will be displayed for the bystander on a stationary 2D screen. The bystander still has no control over the camera but will see a more holistic, less shifting view.
3. Third person POV that is anchored to follow the VR user’s general area of motions will be displayed for the bystander on a stationary 2D screen. The bystander will be able to also move and rotate the camera around the artist through virtual control with a computer keyboard.

4. A motion tracked tablet for the audience to freely move to control the virtual camera in the virtual environment. This is our experimental implementation with physical apparatus.

The conditions clearly differ in their levels of control and holistic awareness of the virtual environment. Given much research was done to support that third person POV allows more situation awareness than the POV one we may choose to extract findings and support for third person views from past research to lessen the experiment time [16]. Similarly, some existing studies point to independent views giving viewers more confidence in usage [15].

The study is within subjects. We will recruit two participants at a session, and randomly assign them to be user or bystander. This approach was done in a similar AR point of view study [15]. We thought this was a better approach for gathering both the user and the bystander’s opinion on the different ways of bystanders viewing alongside an user.

Future Work
Upon completion of the VR Viewfinder project, we have plans to expand the scope and capabilities of this area of research.

Multimodal Immersive Experience
Our original vision was building an environment similar to the CAVE or Allosphere [3, 8], in order to allow a large number of audience members. Allosphere is a large, immersive spherical environment developed by UCSB, and it allows a high number of participants [8]. The CAVE is another example of an environment capable of immersion without headsets. Using multi sided displays in a room, the CAVE gives users a feeling of being realistically physically presented. Also, the user is embodied in their own bodies, enhancing the chances of spatial presence [3]. The issue with surround screen environments is the lack of depth and realistic rendering of nearby virtual objects. If we combine the two approaches, we could perhaps lessen this issue and allow more situation awareness and immersion. For detail of specific objects, bystanders could move around to examine the virtual space with the tracked apparatus. Meanwhile, the larger displays could surround the bystander to give passive immersive exposure, almost like a background in order to provide the holistic picture that a small screen is unable to produce [10].

Audio and Interactions
Sound in virtual reality is almost as significant as vision in improving presence and immersion [2]. Not only will an advanced sound system improve the VR experience, it would improve environmental audio overall. Our hope is to utilize this system to facilitate realistic and comfortable interactions for the VR users and bystanders.

An important future goal for this project is to explore the interactions and emotions between VR users and bystanders. We will use advanced audio capabilities to enhance notification of communication and situation awareness. Depending on the behaviors of people using our system, we could use audio cues to target issues or improve mannerisms in which people engage in this specific approach.

REFERENCES


