MuVR: A Multi-user Virtual Reality Platform

Jerald Thomas*
University of Minnesota Duluth

Raghav Bashyal†
USC School of Cinematic Arts

Samantha Goldstein‡
Swarthmore College

Evan Suma§
USC Institute for Creative Technologies

Abstract

Consumer adoption of virtual reality technology has historically been held back by poor accessibility, the lack of intuitive multi-user capabilities, dependence on external infrastructure for rendering and tracking, and the amount of time and effort required to enter virtual reality systems. This poster presents the current status of our work creating MuVR, a Multi-User Virtual Reality platform that seeks to overcome these hindrances. The MuVR project comprises four main goals: scalable and easy to use multi-user capabilities, portable and self-contained hardware, a rapidly deployable system, and ready accessibility to others. We provide a description of the platform we developed to address these goals and discuss potential directions for future work.

Index Terms: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities

1 Introduction

Collaborative, multi-user VR requires significant effort in terms of lab equipment, software infrastructure, and personalized user configuration. In this paper, we present MuVR, a virtual reality platform that is lightweight, easily configurable, and built entirely with inexpensive off-the-shelf equipment. Additionally, by using mobile hardware mounted on a vest, the system is portable and self-contained, and can be deployed in arbitrary environments without the need for external infrastructure that would be expensive and require tethering through cables.

This work was inspired by previous research performed at the University of Georgia, which shared our goals of using low-cost, off-the-shelf components and maintaining free mobility of the user [1]. In developing MuVR, we attempted to extend the previous work by addressing four main goals. First and foremost, we sought to create a virtual reality platform that is readily accessible for an arbitrary number of multiple simultaneous users. This includes on-the-fly scalability and minimal user configuration. The second goal was to make the system feasible for a wider audience, which requires keeping the hardware cost constrained within a reasonable budget ($800 USD). However, it should be noted that this includes the cost of a smartphone for rendering, which many users own already. The third goal was to have the system be portable and self-contained - not physically attached to anything not worn by the user and not dependant on any hard to move external tracking system. Essentially, we wanted the user to have ample freedom of movement and to relieve the constraint of being in a single room. The fourth goal was to create a platform that minimized the time it takes to setup and configure the system, allowing for a more accessible experience. To achieve this, we sought to package the designs for this platform as part of a do-it-yourself (DIY) kit that anyone can purchase, assemble, and use with minimal technical knowledge.

*e-mail: thoma891@d.umn.edu
†e-mail: bashyal@usc.edu
‡e-mail: sgoldst3@swarthmore.edu
§email: suma@ict.usc.edu

Figure 1: The MuVR system worn by the user.

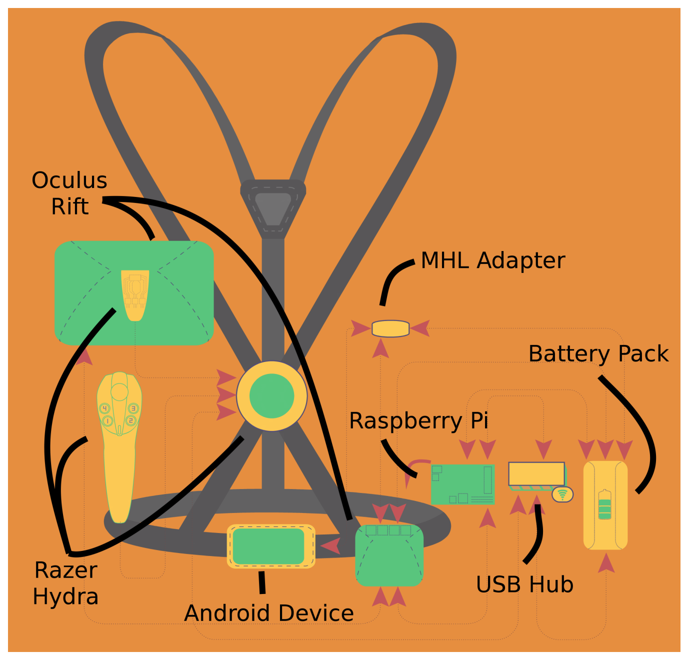

Figure 2: An illustration of the MuVR system with annotations

2 The MuVR Platform

Hardware. In order to meet our goals for accessibility, the decision was made that all components of the platform should be purchasable on the consumer market with as few modifications as possible. Figures 1 and 2 show the various worn components that make up MuVR. We utilize the recently developed Oculus Rift head-

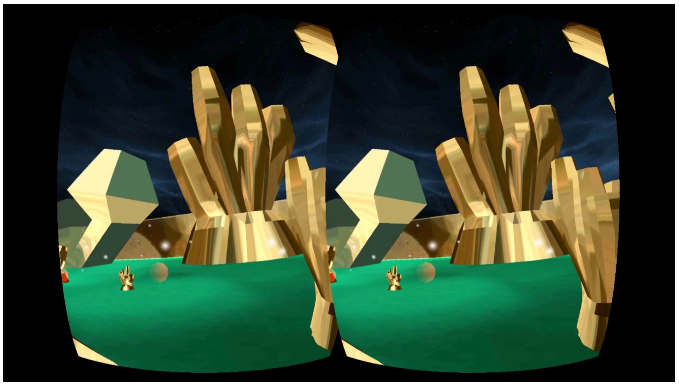

Figure 3: Our demonstration virtual environment as seen by the user in stereoscopic 3D. We currently use low-polygon geometry to optimize the rendering speed on a mobile device.

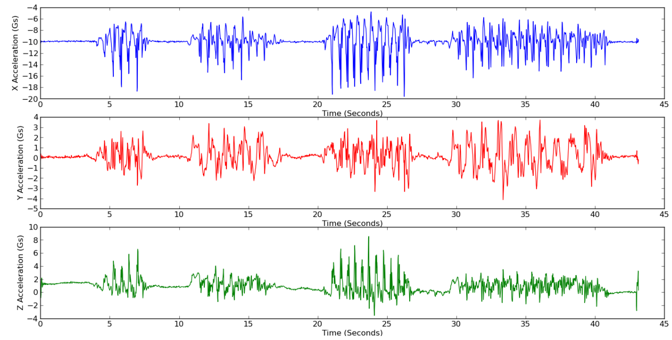

Figure 4: Accelerometer data from the Android device. Here the user is walking in short bursts, shown by the rapid and extreme changes in acceleration, separated by standing still for short periods of time which provides very little change in acceleration.

mounted display. The virtual scene is rendered using an Android smartphone, connected to the Rift's HDMI input using a Cable Matters MHL Adapter. We used three different smart phones to test our setup: the HTC Rezound, the Sony Xperia TL, and the Samsung Galaxy Nexus. Although all three were functional, we experienced the fewest integration problems with the Galaxy Nexus. While the HMD includes an integrated orientation tracker, we desired a 6-degree-of-freedom (6DOF) head tracking so that the visuals would respond realistically when the user leans or tilts their head. Thus, we used a Razer Hydra electromagnetic tracking system, with the base station mounted to the user's back, similar to the approach from [1]. We found that this gives a reasonable volume around the body that can be tracked using the Hydra controllers. We extracted the sensor board directly from one of the controllers and mounted it to the HMD, thereby providing 6DOF tracking of the head relative the body. The other controller can be held in either hand, providing both tracking and input capabilities. The tracking system is connected through a Raspberry Pi single-board computer, which transmits the data over the wifi connection via the Virtual Reality Peripheral Network (VRPN). Tying everything together is a EasyAcc Power Bank 5 volt battery pack, a Gear Head USB 2.0 4-Port Hub, a Edimax EW-7811UN Wifi Adapter, and a multitude of cables.

Software. The software component of the MuVR platform is built using the Unity game development environment. Unity provides the capability to build virtual environments for Android devices, and we implemented packages for stereoscopic render and optical predistortion, as well as a VRPN client plugin that receives tracking data from the Raspberry Pi. The MuVR Android app features a UI that guides the user through setup, and a demo virtual environment (see Figure 3). The app is designed so that a multitude of virtual environments - games, shared spaces, simulations - can be loaded in with ease. Creating a new virtual environment is as simple as importing a 3D model into an empty Unity 3D scene, then dragging and dropping the essential prefabs (readymade Unity objects): the player avatar and networking scripts. MuVR implements a complete self discovery system using UDP broadcasting, which operates as follows. When a user joins the network, the system determines if there is a server already running on the network. If there is, then it joins said server, if not then it creates a server. Once a server is established, it looks for all of the MuVR associated Raspberry Pis on the network, creating a list. When another user joins the network and attaches to the server, the server prompts the user to press a specific button on the Razer Hydra. The server then determines which Raspberry Pi the user controls and assigns that Raspberry Pi to the client. The client then creates a connection to the Raspberry Pi to make use of the VRPN information.

While the Razer Hydra provides 6DOF head tracking relative the user's body, we still need a method of locomotion through the virtual world. To achieve this, the application uses accelerometer and gyroscope data gathered from the Android device attached to the users back. We then calculate spikes in accelerometer data to detect when a user is in motion (see Figure 4). This allows the user to physically walk around without need for walking in place or other simulated locomotion technique which speculatively creates a better sense of presence. The game instance will then move the user forward in the virtual world. While this is not ”true” 6DOF tracking as would be achieved using an external motion capture infrastructure, we found that the combination of 6DOF body-relative head tracking along with accelerometer-based locomotion provides a fairly compelling experience.

3 Conclusion

We believe that MuVR, and other similar portable, low-cost VR platforms, have numerous possible applications in research, training, and entertainment. While, at its current stage, the system is still a proof-of-concept prototype, the availibility of low-cost, off-the-shelf VR equipment is experiencing a dramatic increase. We plan to continually evolve and improve the MuVR platform to best leverage new capabilities - for example, the upcoming STEM system from Sixense will provide wireless tracking capabilities over a greater range than the Razer Hydra. Additionally, advances in consumer head-mounted displays and mobile technology will make it possible to render more highly detailed stereoscopic scenes on portable devices. MuVR is designed to be a multiple user system, and we have performed preliminary testing using two MuVR systems with promising results. Thus, the MuVR platform can serve as an example for researchers and hobbyists seeking to integrate new emerging hardware as it becomes available.

Acknowledgements

The authors would like to thank the University of Southern California Institute for Creative Technologies, the NSF Research Experiences for Undergraduates program, and the members of the ICT MxR Lab during the summer of 2013. We would also like to thank Dr. Pete Willemsen for his helpful input during the writing process of this publication. This material is based upon work supported by the National Science Foundation under Grant No. CNS-1263386.

References

[1] A. Basu, C. Saupe, E. Refour, A. Raij, and K. Johnsen. Immersive 3dui on one dollar a day. In *3D User Interfaces (3DUI), 2012 IEEE Symposium on*, pages 97–100, 2012.