Abstract – Virtual reality (VR) has slowly embedded itself into modern society; it has transitioned from the prestigious research laboratory to everyday life as virtual environments (VE) are being used for entertainment and as an educational tool. How well can current virtual reality hardware display 3D objects? This is the question that we sought to answer with our study, as we tested the ability of the Oculus Rift and a 4K 3D television to display the depth and scale of various 3D virtual models. We believe that the ability to properly display depth and scale can lead to an increase in user immersion and could lead to superior entertainment experiences and enhanced learning capabilities.

I. INTRODUCTION

Since the rise of computer graphics in consumer entertainment in the form of videogames and computer generated images (CGI) in movies and television shows, the dream of a fully interactive virtual environment has grown more obtainable year by year. What once was relegated to fantasies on Star Trek about holodecks has slowly found its way to consumer households through an assortment of devices. 3D capable hardware and virtual environment interaction have found their way into the living room, whether it is in the form of 3D televisions, Nintendo’s 3DS handheld console which is capable of displaying passive 3D, or in the various motion controllers that have been utilized in video games such as Nintendo’s Wii Remote, Microsoft’s Kinect, and Sony’s PlayStation Move controller. There is even Virtuix’s Omni, a device that has the user at the center of a platform and any step they take will be translated to a movement on screen, essentially allowing for one to walk through virtual environments.

Virtual reality (VR) has found its place in research as a tool to test memory retention and as a teaching aid for complex tasks. The United States Army developed and uses a game called America’s Army as a training simulator for its soldiers and as a potential recruitment tool. They have found that soldiers that practice routines and running through an environment using the simulator often have noticeable improvements in the corresponding tasks or scenarios in real life. VR has also been used to teach people difficult tasks, such as allowing doctors to practice various types of surgery without the need of a practice cadaver. Research is being carried out to test VR’s capabilities in aiding in overcoming psychological trauma, physical disabilities, and improving memory functions.

VR is also starting to find its way into entertainment and the arts. As outlined earlier in the paper, consumer electronics, mainly video games, have fully embraced VR as a means to change user experiences and interactions. Whereas graphical fidelity was once the sole measure of a game’s ability to immerse a user in a virtual world, VR equipment has made that task easier. VR
headsets can allow for users to feel that they are truly a part of a virtual environment, if they look down a cliff they can get a sense of vertigo or if they are in a narrow corridor a sense of claustrophobia. These new sensations have caused a reimagining of what games can look and play like, resulting in new genres and experiences being created.

Our research focused on testing the 3D capabilities of the first generation prototype model of the Oculus Rift and a 4K 3D television. We held a user study that focused on the devices’ ability to display the depth and scale of 3D virtual models. The Oculus Rift is a VR headset that allows for primitive head tracking and displaying native 3D content. The Oculus Rift works by rendering visuals on a 7 inch LCD screen inside the headset. Using special curved lenses inside the Oculus Rift the user is able to see a 3D converted image, the computer is rendering two copies of the scene on the LCD screen that are merged together by the lenses. The 4K 3D television used in the study had a screen size of 55 inches and required standard 3D viewing glasses to properly see 3D content.

The same 3D environment was displayed on these two devices and we determined the devices’ ability to display scale and depth with a user study that had participants view a variety of virtual objects and then fill out a short questionnaire on their experience. It was our hypothesis that the Oculus Rift would offer a comparable or better experience than the 4K 3D television, therefore opening up the hardware to be a cheaper alternative to 3D televisions or allow for a consumer to exactly replicate the experience of seeing a 3D movie at the theaters.

The major obstacles we faced with our research was the low visual definition on the Oculus Rift and getting permission for our user study from Connecticut College’s Institutional Research Board in time to meet certain outside deadlines. The visuals seen through the first generation Oculus Rift are of a lower quality than if they were to be displayed on a standard computer screen due to a lower overall resolution on the 7-inch LCD screen. This difference in visual quality can be distracting and might make judging depth and scale harder, though as hardware improves this difference should disappear or be a non factor.

II. METHOD

Participants

Our study was comprised of twenty-one students ranging in age from eighteen to twenty-two years old, with the average age being twenty. 62% of the participants in the study were male and 38% were female. The participants were recruited through email, word of mouth, and through a class talk with permission of the instructor. The amount of experience the participants had with virtual reality hardware and 3D technology ranged from barely any experience outside of seeing a 3D movie in theaters a handful of times to having access to similar types of technologies at home or at college. The twenty-one students were split into two different groups, with eleven students testing the Oculus Rift and the remaining ten testing the 3D TV. The groups were chosen by switching devices after every user.

Materials

The materials used for this study were the first generation development kit for the Oculus Rift, a 4K resolution 3D Television, four different virtual models
composed of a car, a steel barricade, a park bench, and a wooden table all placed inside an empty room created using the Unity game engine. The models could be swapped between one another by pressing certain buttons on the keyboard. A questionnaire was also constructed that asked the participant their age, gender, past experience with 3D technology and how often they watch 3D movies either at home or in the movie theater, how often they used electronic devices in their leisure time, if they experienced any feelings of motion sickness while using their device, how well they could sense the depth and scale of the models, and what they thought the length and height of the models were in feet. If the user used the Oculus Rift they had two additional questions to answer, did they feel any out of body experiences while using the device and would they be open to buying a similar device if given the opportunity.

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The users were brought into our testing room one at a time and then shown the models through the device that they were assigned. The first model that they were shown was the car which served as an introduction to the devices and to see if the user suffered from any immediate motion sickness and wanted to stop using the virtual device hardware. The models were switched between using the keyboard, when the participants wished to switch models we would press the relevant key to switch out the model. Upon either viewing all the models or choosing to exit the environment early, the participants were asked to fill out the questionnaire, with the option to skip any questions they desired. After completing the study the participants were offered food and water that we had in the testing room.

III. RESULTS

The background data on our twenty-one participants reveals that the majority of them own or have used virtual reality hardware in the past. Out of the total number of participants only five claim not to have any notable experience with virtual reality hardware. Though when looking at the data for how often the participants actively use virtual reality hardware or watch 3D developed content, only ten out of the twenty-one participants have some form of regular interaction with these devices in a given month. Outside of one participant, everyone had frequent use of electronic devices, such as computers or video game consoles, in their everyday life outside of a school or work capacity. With the Oculus testers using these devices an average of 4.9 and 3DTV testers using these devices an average of 4.5 on a 5 point Likert scale. Feelings of nausea from using the two devices were nonexistent in our users except for in two cases, one user of the 3D television expressed a feeling of slight nausea and one user of the Oculus expressed mild feelings of nausea, in both cases these feelings dispersed right after the experiment was concluded. We did throw out our data about the user’s perception of the length and height of the models shown, since we did not have exact numbers on the length and height of the models used.

As a whole, the Oculus users were more confident in perceiving a feeling of sense and depth of the objects used in the study compared to their 3D television counterparts. On a 5 point Likert scale Oculus users said they could sense the scale of the objects an average of 4.20 compared to the 3D television users’ 3.90 and for depth of the objects an average of 3.64 for the Oculus and a 3.40 for the 3D television. For the Oculus Rift specific questions the eleven participants on a 5 point Likert scale
said they experienced a 1.27 in terms of having any feelings of an out of body experience or general disorientation while using the device. The majority of users were open to buying the Oculus Rift, but expressed an interest in waiting for more Oculus Rift focused content to be made or in one case wary due to Facebook’s acquisition of the Oculus Rift developers, which occurred the day before our study was conducted.

If we had more time we would have liked to have run the study for a longer period of time and recruited more participants in order to reinforce the data we found.

IV. FUTURE WORKS

We would like to test the same devices using different types of 3D content such as 3D video or moving virtual models. Also we would like to allow the user to move around the environment as the ability to move should change how well they perceive the sense of scale of the object. We did not allow the user to move throughout the virtual environment in an attempt to cut down on the chance of any adverse side effects from the disconnect that can arise between moving in a virtual environment and using a 3D capable device. Typically this is the main cause of motion sickness. We would also like to test the Oculus Rift against other consumer level 3D virtual head displays, such as Sony’s Project Morpheus for the PlayStation 4 that is releasing later this year or in the very least the next iteration of the Oculus Rift prototype.

V. CONCLUSION

Our data backed up our hypothesis that the Oculus Rift would perform at the same level as the 4K 3D television. In fact the Oculus Rift tested better on average than the 4K 3D television. We believe that this divide will only grow as the technology of the Oculus Rift advances, the reports of the second generation prototype already seem to support this as the screen resolution has been increased allowing for a clearer image. The cheap entry cost of the Oculus Rift compared to the 4K 3D television, $300 versus ~$4,000 means that as a consumer product the Oculus Rift should have a better time catching on at a consumer level. Better visuals along with a better capacity for displaying 3D should mean a bright future for VR.

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Appendix

Car Model

Steel Barricade Model

Park Bench Model

Wooden Table Model

A Participant using the 4K 3D television

First Generation Oculus Rift Prototype