Opportunities and Challenges in Virtual Reality for Remote and Virtual Laboratories

MJ.Callaghan, A. Gómez Eguíluz, G.McLaughlin and N.McShane
School of Computing and Intelligent Systems
University of Ulster, Derry
Northern Ireland, UK
mj.callaghan@ulster.ac.uk

***Abstract*— Recent technological advances and consumer level pricing for virtual reality hardware and related peripherals has led to renewed interest in its use for education and training. The design of compelling, effective and practical applications in virtual reality for education is challenging. It adds additional levels of complexity and overheads to the creation of teaching material and to ensuring a positive student experience. This paper (work in progress) explores some of the issues in the use of virtual reality in the context of remote and virtual laboratories and discusses some of the challenges and opportunities of porting existing practical labs and simulations into a virtual reality environment.**

***Index Terms*— Virtual Reality; Engineering Education; Remote and Virtual Laboratories; Game Based Learning.**

I. Introduction

Virtual reality (VR) hardware and related peripherals are increasingly accessible and affordable due to general technological improvements particularly related to mobile devices. This generation of VR devices has the potential to address many of previous shortcomings in the area to become mainstream consumer devices e.g. Oculus Rift, Sony Morpheus and Samsung Gear VR [1-3]. However designing practical applications in VR for effective educational use has many challenges in addition to the recurring problems of motion sickness [4]. Traditional interaction with computers tended to focus on how the user related to and interacted with the content on the screen. VR, when used effectively goes beyond immersion to give the user a sense of presence. Achieving and maintaining this state of presence requires re-examination of interface design inside VR to ensure a compelling user experience.

This paper discusses some of the possible issues of porting an existing electrical and electronic engineering remote/virtual laboratory to virtual reality. It shows how a commercial games engine i.e. Unity3D can be used to prototype virtual environments and examines the availability and usefulness of a range of external hardware peripherals to interact with and navigate effectively in this context.

Section 2 of the paper discusses recent University of Ulster research in virtual worlds and serious games, section 3 looks at general issues related to the practical use of VR, discussed some of the challenges faced and how these are been addressed. Sections 4 looks at a selection of new and upcoming hardware peripherals which can be used to interact with and navigate in virtual environments and the opportunities offered. Section 5 concludes the paper.

II. Game Based Learning in Virtual Worlds

The Serious Games & Virtual Worlds research team at the Intelligent Systems Research Center (ISRC), University of Ulster focus on assessing the potential and effectiveness of video games technologies for undergraduate/postgraduate teaching of electrical and electronic engineering related subjects [5]. The Circuit Warz project was created to investigate if collaborative and competitive game based learning can increase student engagement and retention in these subjects. In the first instance Circuit Warz was built using the Unity3D cross-platform games engine developed by Unity Technologies for deployment in a web browser. The game used a mouse and keyboard for player control and interactions in the game world. Figure 1 shows screenshots from in-world game play, (in this instance from level 5 of the game, the weighted sum amplifier).

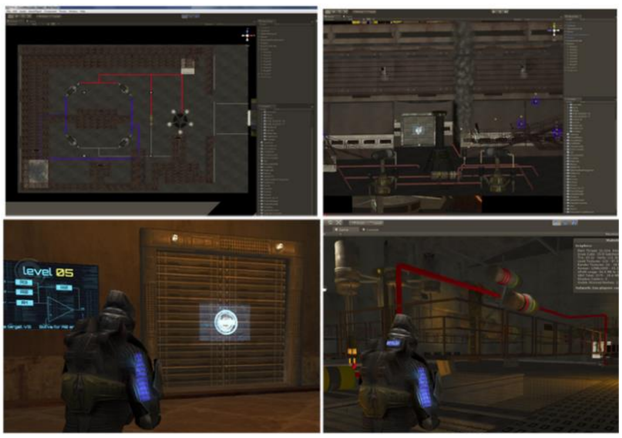

Figure 1. Theoretically correct physical layout of in-game and real world circuits in level 5

The game was subsequently optimized for deployment on mobile devices platforms with touch capabilities [6]. The character/game was redesigned using a first person perspective and viewpoint which allowed the player to navigate the game world in a more intuitive and easy to use fashion (Figures 2 and 3). Navigation and movement in the game world was through the use of a virtual joystick and touch/tap/swipe controls for in-world interactions i.e. opening doors, connecting circuits and using the heads up display for contextual information on game state, current and future objectives and overall progress.

Figure 2. First person perspective level 3 Diode circuit

Figure 3. Level 6 Summing amplifier

III. DESIGN CONSIDERATIONS IN VIRTUAL REALITY

Designing games or interactive simulations for virtual reality environments is challenging on a number of levels. High end, premium AAA video games tend to very intense, fast paced and action packed. In a VR setting it is essential not to overwhelm the player in the first instance as overall intensity will be magnified (Figure 4).

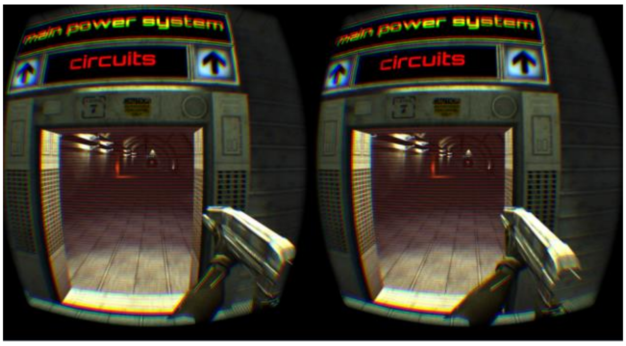

Figure 4. Circuit Warz ported to Oculus Rift

The designer has to ensure that the player experience is good i.e. limiting the feeling of vertigo, claustrophobia and easing the player into the game world. Each player will have different tolerance levels so the game needs to be tested from a very early stage and regularly (Figure 5). The designer also needs to maintain the sensation of presence and flow for the player while leveraging the psychological and physiological features of the virtual space [7].

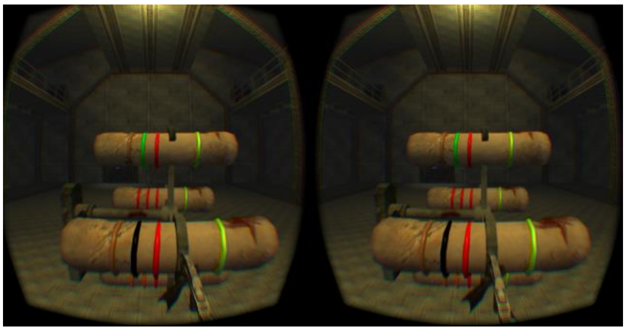

Figure 5. Circuit Warz level 6

More importantly the designer should adhere the cardinal rule of virtual reality and not take control of the camera from the player unless absolutely unavoidable. In terms of hardware there are a number of considerations to take onboard e.g. the Oculus Rift DK2 has a 1920x1080 OLED screen with a wide angle lenses (field of view between 90-110 degrees) and a low persistence display which is only lit for 3ms per picture ensuring the image shown is generally correct for the current head position. The main consideration is to ensure the frame rate always stays above 75 hertz by removing unnecessary detail or reducing resolution [8].

IV. HARDWARE PERIPHERALS

There is considerable investment and research at the current time in this area as the main players (Oculus Rift, Sony and Samsung) attempt to get a viable consumer product to a mainstream audience. In the broader virtual reality ecosystem a number of companies are releasing complementary products that may be useful for use in virtual/remote laboratories. The Leap Motion VR kit (Figure 6) is a mount for the companies PC peripheral that lets you track your hands in virtual reality applications by attaching it to the front of the Oculus Rift or similar headsets [9].

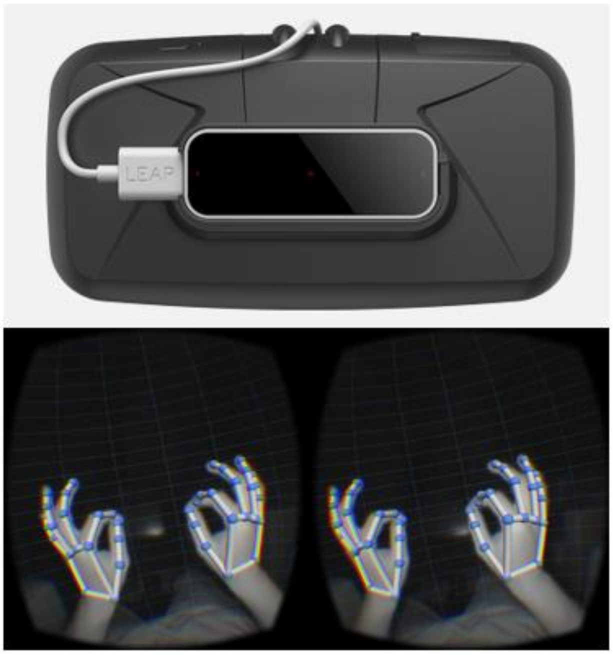

Figure 6. Leap Motion VR system

The Virtuix Omni treadmill (Figure 7) allows players to move freely and naturally inside the virtual environment [10], the Sixsense STEM system (Figure 8) which attempts to provide full body presence in virtual reality [11].

Figure 7. Virtuix Omni treadmill

Figure 8. Sixsense STEM system

V. CONCLUSION

This paper provided a brief overview of ongoing research and work in progress at the School of Computing and Intelligent Systems, University of Ulster, Northern Ireland into the use of virtual reality environments for teaching electronic and electrical engineering. The Circuit Warz project was presented and some considerations and possible issues related to porting the game over to a virtual reality platform discussed. A number of external hardware peripherals currently been evaluated for future use in the Circuit Warz project was introduced. Research in this area is ongoing and evolving as new software tools, headsets and hardware peripherals become available.

REFERENCES

[1] Oculus Rift: Virtual Reality Headset for 3D Gaming [Online] Available from: http://www.oculus.com/ [Accessed: 19th November 2014]
[2] Sony Project Morpheus: [Online] Available from: http://www.officialplaystationmagazine.co.uk [Accessed: 19th November 2014]
[3] Samsung Gear VR: [Online] Available from: http://www.samsung.com/gearvr/gearvr_features.html [Accessed: 19th November 2014]
[4] Chen, W., Chen, J.Z: Visually Induced Motion Sickness: Effects of Translational Visual Motion along Different Axes, Contemporary Ergonomics and Human Factors, CRC Press, 2011, p.281-287
[5] M.J. Callaghan, K. McCusker, J.L. Losada, J.Harkin, S. Wilson.: Using Game-Based Learning in Virtual Worlds to Teach Electronic and Electrical Engineering, IEEE Trans. on Industrial Informatics, vol. 9, no. 1, pp. 575-584, Feb 2013.
[6] Callaghan, MJ, Gómez Eguíluz, A. and McShane, Niall. Using Game Analytics to Measure Student Engagement/Retention for Engineering Education.11th International Conference on Remote Engineering and Virtual Instrumentation REV 2014
[7] Game Design in VR: Pushing Off from a New Frontier [Online] Available from: http://gamasutra.com/blogs/KimberlyVoll [Accessed: 19th November 2014]
[8] Developing Virtual Reality Experiences with Oculus Rift [Online] Available from: http://www.roadtovr.com [Accessed: 19th November 2014]
[9] Leap motion VR system [Online] Available from: https://www.leapmotion.com/ [Accessed: 19th November 2014]
[10] Virtuix Onmi treadmill [Online] Available from: http://www.techspot.com/news/ [Accessed: 19th November 2014]
[11] STEM System | Sixense [Online] Available from: http://sixense.com/wireless [Accessed: 19th November 2014]

AUTHORS

Michael Callaghan is a Reader at the University of Ulster, Northern Ireland and leads the activities of the Serious Games and Virtual Worlds research team at the Intelligent Systems Research Center. **Gavin McLaughlin** is a researcher in games at the center. **Niall McShane, Augusto Gómez Eguíluz** were placement students in virtual worlds at the Intelligent Systems Research Center Research Center, University of Ulster.