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Virtual Reality Drumset

Head-Mounted Displays for Immersive Virtual Reality Systems

Introduction

Immersive virtual reality(VR) systems rely on technology that submerges the perceptual system of the user in computer-generated stimuli[1]. Stereoscopic head-mounted displays(HMD) comprise one of the distinctive features of the hardware underlying these systems. The HMD depicts a wide-angle stereoscopic visual environment. Such environments have various cost-reducing applications including problem solving, simulations, prototyping and experimentation in education, training, business, entertainment, military, medicine, science and architecture[2]. This paper reviews commercially available headsets and explains how they can be used to implement immersive VR systems.

Commercial Applications of Immersive Virtual Reality Systems

There are a few commercially available headsets available in the market. The Oculus Rift is a top-of-the line product of the startup Oculus VR, which was taken over by Facebook in July 2014. The latest model of the Oculus Rift($350), called Crystal Cove, has an OLED display screen of 1080p resolution. Its primary purpose is gaming and it gives a 100°field of view(FOV). Project Morpheus($1000), a PS4 product by Sony, has an LCD screen of 1080p. LCD screens have slower response rates than LCD screens; LCD has a response rate of 16ms, whereas OLED can have a response rate as low as 0.1ms[3]. Latency is vital for head tracking. Head tracking provides an interface for navigation in 3D space and provides capabilities to look around and move in virtual environments[4]. The Oculus Rift and Project Morpheus employ similar ways of performing head and motion tracking. Additionally, they both use readings of an accelerometer and a gyroscope. The Oculus Rift uses an additional sensor, the magnetometer, for greater accuracy[3].

Another competing design of headset is the Google Cardboard, a project undertaken by Google. The commercially available cardboard viewer, or the headset, is available the most inexpensive headset($19.99) on the market. It allows users to experience a VR environment via applications on smartphones and browsers. Like the Oculus Rift, it consists of a magnetometer.

Technology of a Rudimentary, Inexpensive Headset

The Google Cardboard is fully compatible with most Android phones and a comprehensive list is available[6]. The Cardboard is a three part system, comprising of a viewer, a smartphone and a software development toolkit(SDK) to build VR applications for the smartphone.

Hardware

It is also possible to construct a viewer according to user specifications since basic requirements for the viewer are listed on the official website[6]. The cardboard viewer should be of size 8.74x22x0.06 inches and lenses should have 45mm focal distance; biconvex lenses prevent distortion around the edges. The viewer must also have a Near Field Communication(NFC) tag, which toggles between normal and stereo mode on the smartphone. This tag can be used for hardware modifications of parameters such as interpupillary distance[7]. Lastly, Neodymium and ceramic disk magnets are needed for the Android app, but not for Chrome experiments[6,7].

Software APIs and Development Principles

Phone applications can be built using the open source developer toolkit(SDK) provided on the website[6]. Chrome experiments, an online showroom of interactive web browser programs, can be used to build simple applications on the browser[7]. Open source technologies such as Javascript, HTML5 and WebGL can be used in conjugation with libraries, such as three.js for 3D rendering of objects.

The four basic steps of rendering a pipeline include estimating eye positions, rendering the scene, correction of lens distortion and displaying side-by-side in stereo[7]. The toolkit provides support for all steps except for rendering of the scene from world space to eye space. Additionally, there are a few principles involved in building a VR Android application. Physical motion and visual motion need to be closely coupled. The brain has two systems of motion detection - the visual and the vestibular. Both these systems need to be in sync for the illusion of a VR environment to exist. This involves keeping the viewer at a fixed position or moving at a constant velocity. Users should also have the illusion of a 180° field of view.

Finally, the convincing illusion of being fully immersed in the virtual world can be enhanced by auditory, haptic and other non-visual technologies[4]. Additional hardware such as a 3D stereoscopic sound system may be employed[8].

References

[1] Frank Biocca, Mark R Levy, "Communication in the Age of Virtual Reality". 2008 [Online] Available: http://books.google.com/books?hl=en&lr=&id=MzaMSbzcz6UC&oi=fnd&pg=PA57&dq=immersive+virtual+reality+applications&ots=Vqf9-XeRBR&sig=LhgUHCCLpEHpfKSYK6DH4jMvK7c#v=onepage&q=immersive%20virtual%20reality%20applications&f=false

[2] Samuel Ebersole, "A Brief History of Virtual Reality and its Social Applications". 2009 [Online] Available: http://faculty.colostate-pueblo.edu/samuel.ebersole/336/eim/papers/vrhist.html

[3] "Oculus Rift vs Project Morpheus". RetrievedJanuary , 2014 Available: http://www.trustedreviews.com/opinions/oculus-rift-vs-project-morpheus

[4] "Virtual Reality: A Short Introduction". RetrievedJanuary , 2014 Available: http://www.iwayan.info/Lecture/GrafikKomputer2_S1/P13_IntroVirtualReality1.pdf

[5] "Sony Computer Entertainment Announces "Project Morpheus" - A Virtual Reality System That Expands The World Of Playstation®4 (PS4™)". Retrieved January , 2014 Available: http://www.sony.com/SCA/company-news/press-releases/sony-computer-entertainment-america-inc/2014/sony-computer-entertainment-announces-project-morp.shtml

[6] Google Cardboard Official Website, 2014 Available: https://cardboard.withgoogle.com/

[7] Google I/O Conference , 2014 Available: https://www.youtube.com/watch?v=DFog2gMnm44

[8] The Sound Design Process. RetrievedJanuary , 2014 Available: http://thesounddesignprocess.wordpress.com/2012/06/01/tridimensional-reproduction-of-sound-pure-stereo-3d-audio/