A GUIDE TO THE TECHNOLOGIES, APPLICATIONS, AND HUMAN FACTORS FOR AR AND VR

Practical AUGMENTED REALITY

Steve AUKSTAKALNIS

Praise for *Practical Augmented Reality*

"A valuable addition to the library of anyone setting out on their virtual journey."

—Dr Rab Scott
Head of VR, Nuclear AMRC

"A well-presented introduction to advanced visualization technologies, which will provide readers with an informed overview of this fast-paced, high-tech industry."

—Chris Freeman
Augmented Reality Technical Fellow, University of Sheffield AMRC

"Filled with excellent, imaginative information that will inform both experienced and first-time readers alike. *Practical Augmented Reality* is worth reading not only for its wealth of data and research, but also for its insights into the markets and opportunities ahead of us. If you have an interest in this exciting new technology, this is a must-have resource and an enjoyable exploration into this brave new world."

—Roy Taylor
Corporate Vice President for Content and Technology, AMD (Advanced Micro Devices)

"Steven Aukstakalnis stands on the ever-changing edge of the virtual and augmented reality world. Drawing from a rich history in the industry, he is able to share a clear understanding of the technologies, products, and ideas that will reshape the way we work and play. May the knowledge he shares empower you to help create a truly fantastic new future!"

—Brent Baier
Creator of the Peregrine Glove

"Mixed or augmented reality is a grand frontier not only for computation, but for how people experience their world and each other. This book sets a frame around that which isn't framed. Read it in order to understand our new world."

—Jaron Lanier
Author of *Who Owns the Future* and *You Are Not A Gadget*

OSVR–Open-Source VR Development Kit

One of the surefire ways for the newly emerging virtual and augmented reality industry to slow its own growth is by limiting interoperability between applications and peripheral devices. If gaming or professional software applications, or peripherals, are limited to only one platform or system, things become highly problematic and inconvenient for end users and adoption slows.

By inspiring developers to adopt basic standards early on, greater interoperability is achieved, resulting in faster growth of the industry. It is this particular strategy that has led to the development of OSVR (Open Source Virtual Reality), an open source hardware and software ecosystem for virtual reality development efforts.

The hardware system, known as the Hacker Development Kit and shown in Figure 6.5, consists of a high-quality stereoscopic, wide FOV head-mounted display and the associated cabling. The core of the display is based on a single low-persistence 1080p AMOLED panel (divided in half for separate left- and right-eye views) and crisp, custom design dual-element aspheric optics (lenses whose surface profiles are not portions of a sphere or cylinder). A powerful addition to this display is the diopter (focus) adjustment, a feature lacking in most other head-mounted displays covered in this chapter. Tracking the position and orientation of the display is enabled using an internal nine degree-of-freedom IMU along with a camera that tracks a faceplate embedded with IR LEDs.

Other innovative features for this display include the ability to convert a regular desktop video signal into side-by-side mode so that it can be viewed in the goggle, as well as the ability to accept both 1080 1920 and 1920 1080 video signals. This lets you use the display with a wireless video link.

Figure 6.5 Developed by Razer and Sensics, the OSVR development kit is an open licensed ecosystem intended for use in creating VR experiences across any operating system, including Windows, Android, and Linux.

Credit: Images by Maurizio Pesce via Flickr under a CC 2.0 license

The intent behind the release of this display hardware is to provide developers a wide open, nonproprietary platform for their own system development and testing. All aspects of the display have been designed to be hackable, including the actual designs themselves, which are freely available for download. More detailed specifications for the hardware components can be found in Table 6.4.

Table 6.4 Razer/Sensics OSVR HDK HMD Specifications

Feature	Specification
Ocularity	Binocular
Image Source	Single Panel AMOLED
Resolution	Full Panel: 1920 1080p Each Eye: 960 1080p
Refresh Rate	60 fps
Display Optics	Dual-element design for < 13% distortion
Field of View	100°
Eye Relief	13 mm
Interpupillary Dist.	Nonadjustable (large eye box accommodates 57–71 mm)
Head Tracking	9 DoF IMU + IR-LED Faceplate and Camera
Tracking Area–	—
Built-In Camera	No
Microphone	No
Connectivity	(3) USB 3.0 Ports—(1) internal, (2) External

(XinReality, 2016)

OSVR is also a software framework. The OSVR API is a platform-agnostic, standardized interface for virtual reality display devices and peripherals. Intended to serve the role of middleware, the OSVR application programming interface (API) is a set of high-performance rendering and device abstraction services enabling augmented reality/virtual reality (AR/VR) applications to provide near-universal support between head-mounted displays, peripherals such as input devices and trackers, and operating systems.

Smartphone-Based Displays

It is without question that one of the key fields enabling a resurgence of virtual reality is mobile telephony. From the ever-increasing performance of mobile processors, to display manufacturers continually packing more pixels into a given screen area, to the introduction of entirely new classes of sensors, these developments have broken through some of the long-standing barriers haunting this field, and in the process, unleashed a wellspring of creativity. One of the highest impact results is the development of simple tools that enable the use of smartphones themselves as the primary platform upon which to drive immersive simulations.

In this section we explore two of these smartphone-based display systems. Although there are dozens of manufacturers for these devices, each with its own take on the overall design, optics, materials, and added capabilities, most have been introduced as a result of the profound success of those appearing in this section.

Google Cardboard

Disruptive innovation is a term originally coined by Harvard Professor Clayton Christensen. It describes a process by which a product or service takes root initially in simple applications at the bottom of a market and then relentlessly moves up market, eventually displacing established competitors.

In the case of Google and its mid-2014 introduction of a smartphone-based virtual reality headset made of cardboard, cheap biconvex plastic lenses, a magnet, washer, and a few tabs of Velcro (see Figure 6.6), shockwaves were sent through high-tech centers around the globe, and in particular, through the meeting rooms of companies still trying to get their higher-end, PC-driven virtual reality displays into consumer hands. Now anyone with $15 and a smartphone could experience virtual reality (albeit in relatively crude form) and even get started developing their own applications with the basic software development kit (SDK) released at the same time.

After the initial shock passed, most industry participants realized that Google's action, while possibly a joking prod at Facebook for its $2 billion dollar purchase of Oculus not three months earlier, was also one of the most intelligent and high-impact moves this field could experience. Suddenly, there was a means available to allow the masses to experience at least a taste of what high-performance immersive virtual reality systems were capable of delivering once they entered the marketplace. The net effect was a massive jump in public awareness and enthusiasm, not to mention the rapid formation of several dozen new companies looking to get involved at some level, be it through producing their own kits with more durable display housings for sale or new content and app providers. As will be covered in Chapter 18, "Education," Google itself has launched a program known as Google Expeditions within which educators in the K-12 sector now make use of the cardboard viewers to engage their classes in virtual field trips. As of November 2015, more than 100,000 students in schools around the world have used Expedition cardboard viewers in their courses.

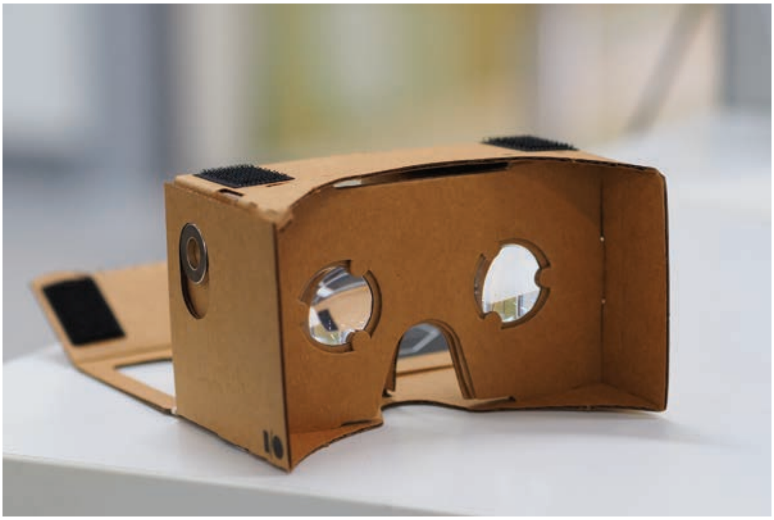

Figure 6.6 A Google Cardboard headset is a cheap and easily accessible standard for experimenting with virtual reality.

Credit: Images by othree via Flickr under a CC 2.0 license

Samsung GearVR

Whereas Google Cardboard and similar devices represent the low end of the smartphone-based display market, the Samsung GearVR device clearly dominates the higher end market. Developed in collaboration with Oculus VR, the headset was first unveiled in late 2014 and released for sale in 2015.

As shown in Figure 6.7, the GearVR headset serves as a viewing device and controller into which any of Samsung's flagship mobile devices can be securely mounted. The system optics expand the display to encompass a 96° horizontal FOV with adjustable focus. Movement of the user's head is tracked across three axes (roll, pitch, and yaw) using an internal IMU with a higher precision than that provided by the IMU within the mobile device. The power for this sensor as well as the side-mounted controls including a touchpad and back button is supplied by the mobile device via a microUSB connection.

More detailed specifications for the Samsung GearVR headset can be found in Table 6.5.

Figure 6.7 Samsung Gear VR is a mobile virtual reality headset developed by Samsung Electronics in collaboration with Oculus VR. The device serves as a housing and controller for any of a variety of Samsung smartphones that acts as the headset's display and processor.
Credit: Images by S. Aukstakalnis

Table 6.5 Samsung GearVR Display Specifications

Feature	Specification
Ocularity	Binocular
Image Source	AMOLED (using recommend mobile devices)
Resolution	Varies based on compatable mobile device.
Refresh Rate	60 Hz (content dependent)
Display Optics	Single biconvex (each eye)
Field of View	96°
Eye Relief / Focus	Eye relief fixed, focus adjustable
Interpupillary Dist.	Accommodates 55–71 mm (nonadjustable)
Head Tracking	3 DoF IMU (gyroscope, accelerometer)
Controls	Touchpad, back key, volume key + Bluetooth (via mobile device)
Audio	Via audio jack on mobile device
Connections	microUSB
Add'l Sensors	Proximity (Mount/Unmount Detection)

(*Continued*)

Table 6.5 (Continued)

Feature	Specification
Weight	318 g (.70 lbs.)
Compatible Devices	Galaxy S7 Galaxy S7 Edge Galaxy Note5 Galaxy S6 Galaxy S6 Edge Galaxy S6 Edge+

(Samsung, 2016)

CAVES and Walls

A variety of large-scale, fixed location immersive displays exist for use within the scientific and professional communities. These systems come in a variety of geometries and sizes, including multisided (or multiwalled), rear-projection, or flat panel-based displays, single and multiprojector hemispherical surfaces, and more, each typically displaying field sequential stereo imagery at high resolutions. Most are designed to accommodate multiple users, each of whom wear LCD shutter glasses controlled by a timing signal that alternately blocks left- and right-eye views in synchronization with the display's refresh rate. Most systems incorporate some method of tracking the position and orientation of a lead user's head to account for movement and to adjust the viewpoints accordingly. In such multiuser scenarios, all other participants experience the simulations in 3D, but passively. An example of one such display is shown in Figure 6.8.

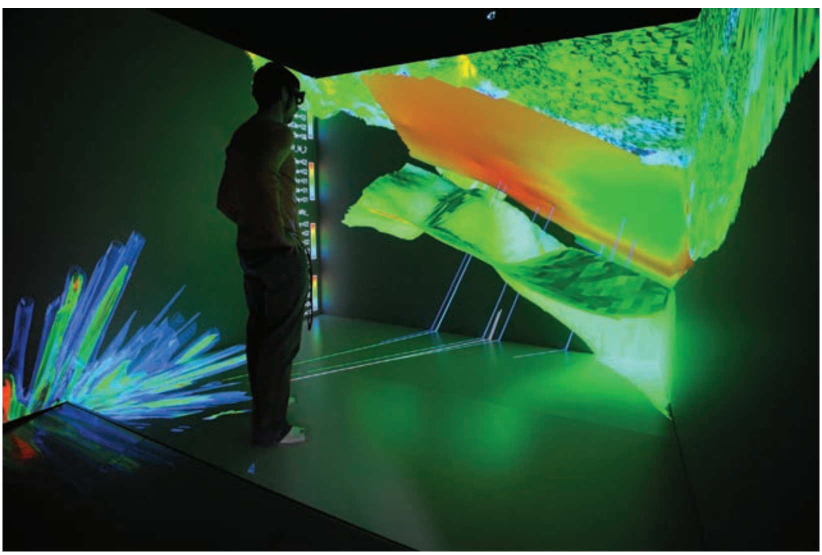

Figure 6.8 In this image a research scientist with Idaho National Laboratory views a subsurface geothermal energy model within a computer-assisted virtual environment (CAVE) display.
Credit: Image courtesy of Idaho National Laboratory