CHAPTER 16*

Virtual Reality Library Environments

Jim Hahn

Introduction

What is virtual reality (VR), and how does it impact the research and teaching missions of the modern academic library? The *Horizon Report,* a resource that provides an annual accounting of technologies and trends relevant to higher education, has listed virtual reality as a technology that will likely be impacting higher education in the next two to three years (Johnson et al., 2016). The 2016 *Horizon Report*'s higher education edition defined VR as "computer-generated environments that simulate the physical presence of people and objects to generate realistic sensory experiences" (Johnson et al., 2016, p. 40). Related to the significance of technologies such as these, the *Horizon Report* authors note, "VR offer[s] compelling applications for higher education; these technologies are poised to impact learning by transporting students to any imaginable location across the known universe and transforming the delivery of knowledge and empowering students to engage in deep learning" (Johnson et al., 2016, p. 40).

However, while enthusiasm for virtual reality among educational technologists is high, the field of VR specifically for teaching and research applications is rather new, and so the educational application of VR is partly conceptual at this time. There are a variety of immersive games that are just becoming available on the consumer market. These early consumer products are illustrative of what will be possible with the new VR hardware released, or soon to be released, by several large technology corporations, including Sony, Facebook, and HTC. This chapter will review VR hardware, VR apps that are currently available, and hypothetical use cases for VR's application to research and teaching within library settings. The chapter will conclude with a summary of development requirements related to software design in VR, thoughts on future directions, and issues related to staying up-to-date with VR technologies in the future.

General Virtual Reality Hardware

When technologists discuss VR hardware, there are several commonly agreed-upon technology solutions at play that incorporate a VR system. In virtual reality systems, the common technology solution is the headset. Headsets act to make the VR experience totally immersive. Unlike augmented reality (AR) applications, VR does not combine elements with the real world, a key exemplar of how VR is a truly immersive experience. Hardware requirements also include dedicated PCs with VR headsets, specific operating systems (OSs), and higher end graphics processing units (GPUs). These higher end graphic processors are required for processing the visual elements of an immersive world.

This chapter will highlight several notable new developments of compelling VR technologies in this area, with a specific focus on how these may be used or adapted to libraries. The specific VR consumer electronics reviewed in this chapter include Facebook's Oculus Rift headset (https://www.oculus.com/en-us), the HTC Vive (https://www.htcvive.com/us), and Sony's PlayStationVR3 (https://www.playstation.com/en-us/explore/playstation-vr). For a low-cost VR option and budget-constrained library IT department, a review of the mobile phone–based VR option Google Cardboard and its associated applications (https://www.google.com/get/cardboard/apps) is also provided.

Contemporary Virtual Reality Hardware

The Oculus Rift (or as it is more commonly known, "the Rift") is one of the more popular contemporary VR systems to come to the awareness of library technologists. The Rift received much public acclaim and attention when news emerged that Facebook would acquire the Oculus company and brand (Solomon, 2014). Facebook made the acquisition in 2014 when a handful of contemporary VR headsets that comprise current consumer end products were still in the early stages of development. In 2014, VR headsets were mostly high-fidelity prototypes. However, as recently as the first quarter of 2016, consumer-ready VR products for the Rift were shipping to users. In order to use the Rift, the user must have a high-end computer with enough graphics processing available for rendering the virtual environment to the headset. To this end, the Rift website will also sell Rift-ready PCs. Common uses for the Oculus Rift are currently viewed as primarily gaming-based (Reisinger, 2016). However, with software development kits (SDKs), it is not out of the realm of possibility that other uses will come online shortly, a possibility that we'll explore further later in this chapter.

The HTC Vive is similar in nature to the Oculus Rift with regard to its configuration, since it requires a high-end graphics processer enhanced PC (Apple compatibility was not available at the time of this writing) in order to experience VR through the headset. Where the HTC Vive differentiates itself is that it allows a greater range of motion than is available from the Rift, which is generally considered a seated experience and not truly motion-enabled for the user. The HTC Vive, on the other hand, allows for a more active and motion-based experience. Reports indicate that users experience the feeling of truly walking through a virtual world and reaching out to touch objects (Eadicicco, 2016). By comparison, within the Oculus Rift, a game controller or a touch-enabled handheld device is required for touch experiences (Eadicicco, 2016).

One final product that experts in this field are following closely is the widely anticipated PlayStation VR. At the time of this writing, the PlayStation VR is not yet available to consumers and is anticipated to come to market in October 2016 (Weiss, 2016). The cost of the PlayStation VR is expected to be $399, which is a lower price point than the Oculus Rift ($599) and the HTC Vive ($799).

Google Cardboard Virtual Reality Experience

Google Cardboard is a unique approach to VR experiences, which extends VR to a wider user base by leveraging existing mobile phone hardware at a fraction of the cost. The cardboard unit, or "viewer," is a product that can be ordered for as little as $20, and it simply uses a mobile phone to slide into the display case (https://www.google.com/get/cardboard/). Once users slide a mobile phone that is compatible with the Cardboard App into the viewer, they are able to hold the viewer to their eyes so that they are able to experience an immersive virtual reality scene, similar in nature to the VR headsets described above.

There is also a Google Cardboard SDK available for developing Cardboard apps (https://developers.google.com/cardboard/overview). Not every library will want to pursue this route, or if a library chooses to develop Google Cardboard apps, it may want to do so either as a part of a research grant; by outsourcing the coding to a developer group with previous Android development; or by or partnering with computer science research teams through which students may provide original and novel ideas toward library services. An alternative to the Cardboard experience is the Samsung Gear VR (http://www.samsung.com/global/

galaxy/wearables/gear-vr), which utilizes a Samsung phone and is built on similar technology to the Oculus Rift.

Review of Virtual Reality Applications and Current Academic Uses

Google's Tilt Brush (http://www.tiltbrush.com) is a virtual reality app that may find uptake among artists, art students, and art researchers. At the time of this writing, the Tilt Brush app is available for the HTC Vive (http://www.fastcompany.com/3056668/googles-tilt-brush-is-the-first-great-vr-app).The demonstration of the Tilt Brush app shows a user totally immersed in making art, and the canvas is the virtual environment imposed all around. The user of this app therefore has a full range of motion to create. We may think of artists as being the natural users of this app, but there may be researchers in human development or ergonomics who wish to study user motion who may also find research and teaching uses with a compelling new application like the Tilt Brush.

The field of art history is seeing instruction-based VR use. A recent interview, entitled "The Promise of Virtual Reality in Higher Education," by Bryan Sinclair and Glenn Gunhouse, provides an accessible overview of several focused experiments in art history pedagogy with VR. Gunhouse has been working for a number of years to bring virtual worlds into art history teaching (http://www2.gsu.edu/~artwgg/atmos.htm). Among the projects he is bringing to art history teaching is the notion of teaching ancient Roman historical principles from "within" those objects, like a Roman house lecture taking part in a virtual world that recreates an ancient Roman house. Gunhouse notes that "what VR offers to my students is an increasingly true-to-life way of visiting places that we otherwise could not visit, either because they are very far away, or because they no longer exist" (Sinclair & Gunhouse, 2016). At this time Gunhouse says that the only thing holding back the full class from taking part in the VR-based lecture and learning is available equipment: "the lack of a classroom equipped with the necessary hardware" (Sincalir & Gunhouse, 2016).

Journalism is another discipline in which VR has found uptake by early adopters. As an example, there is a Cardboard app that the *New York Times* developed to tell stories in a more immersive way than would be possible with current mobile-based applications (http://www.nytimes.com/newsgraphics/2015/nytvr/). Being able to more fully tell a story is not solely relegated to journalism since digital presentations in many disciplines will rely on conveying information in a compelling way. Writing, communication, and rhetoric studies may also find uptake of the app by practitioners and students looking for new ways to engage their audiences.

The uses of VR for medicine are particularly intriguing for the ability to simulate complex human organs and the education of those who will be involved in surgical planning and surgical operation (Greenleaf, 1995). A variety of medical applications have already been reported on, from helping to treat anxieties like fear of flying to the development of treatments for PTSD (Carson, 2015). Uses in applied psychological studies have been reported, specifically in a case study where implications on the student of visual perception are explored (Wilson & Soranzo, 2015). One area within visual perception research made possible by VR headsets is new research examining visual illusions. Consider the types of visual illusions that perception researchers have made use of in their work, but applied in an immersive environment where the user is moving. Traditional studies of illusions on visual perception seemed to begin from the starting point that study participants were not moving or their movement was not an object of study—which is something the VR allows researchers to investigate (Wilson & Soranzo, 2015).

It is also the case that several STEM fields will have applications available soon for VR as well, due to these fields' needs for spatial and visual intelligence training. One recent report on utilizing virtual technology for engaging engineering focuses in the area of teaching mathematics and aerospace concepts to undergraduates (Aji & Khan, 2015). The authors of the work, "Virtual to Reality," describe using immersive experiences with flight simulation in order to engage teams of undergraduate students collaborating on test flight modules (Aji & Khan, 2015).

Library Virtual Reality Use Cases for Research and Teaching

There are several virtual reality uses cases for research and teaching specifically within the library. In this section we review first-year-experience programming for VR, digital access to vendor content like e-books through VR, and data visualization and VR and conclude with thoughts related to makerspaces and VR production within libraries.

First-Year-Experience Programming

The delivery of typical first-year-experience instruction has shifted over time as new technology has become available. What was once a tour of the building in person moved to online virtual tours as well as various introductory content about the library being available to students remotely. One of the first early exemplars on virtual worlds and library outreach was undertaken with experimental Second Life environments (Stimpson, 2009). Second Life is an online virtual world in which users can control avatars that can interact with other avatars and environmental objects. In these virtual environments, accessible from a browser, users navigated a multiuser world, including virtual library buildings and spaces that were designed by library staff. Though Second Life was not primarily designed for library outreach, practitioners were engaged in creating virtual library outreach where users could come to experience in Second Life another "branch" of the library. These branches were not heavily used, and not all libraries made efforts to develop programming specifically targeted at this VR branch (Stimpson, 2009). More recently, Second Life developers have worked to use Oculus Rift to explore Second Life (Linden Lab, 2014). Whether the new Oculus Rift–based gateway into Second Life will convince more users and library practitioners to try the virtual world remains to be seen.

Self-guided podcast and iPod app tours have also been utilized as a novel technology to provide tours and introductions in libraries (Mikelle & Davidson, 2011). This provides an example of the historical continuities among older technologies and new, emerging consumer products that have been able to provide new or more efficient services. Library technologists may be interested in developing immersive virtual library and virtual campus tours that take place beyond the campus. If they do so, students who are excited about visiting campus and are not nearby can plan a virtual reality visit. This can help drive down travel costs for students so that they are required to make the trip to campus only when they begin their studies. Partnerships with admissions departments and other new-student programs are advisable, since these groups will be stakeholders in any technology application that helps recruit students to campus. Pooling resources can help to defray development costs and help to promote innovative design ideas.

HoloBooks: E-book Reading in Virtual Reality Environments

The challenges facing academic libraries to continue to steward print resources while investing heavily in online content has led many in the public sphere, as well as from the academic library profession, to question the need and use of legacy print collections. Lee, in the classic work "What Is a Collection?" evaluates this intermediary state of collection development and argues compellingly for redefining collections in libraries as information contexts (2000). Researchers at the University of Illinois library have begun crafting a project to develop virtual reality e-book reading experiences allowing library users to explore and read e-books from virtual worlds. The proof-of-concept system was initially targeted at the Microsoft HoloLens, a mixed-reality technology. The Microsoft HoloLens does not qualify as a truly immersive VR experience, since it uses targets in the real world along with a headset to create projections of digital surrogates onto real-world items.

The premise of the HoloBook project is to develop functionality to generate a page on a physical paper-like target to mimic reading a printed item. HoloBooks could apply to several or all of the VR headsets described in this chapter. Rather than using a paper-like target in the case of the Microsoft HoloLens, the completely immersive VR environment would handle all of the rendering and display of a HoloBook.

Development of HoloBook features will include emulating page turns, annotations, and highlighting functionality. By developing the HoloBook reading experience, researchers are interested in testing the hypothesis that reading digital items from print-like surrogates can support increased comprehension of text. Of relevance to the research and teaching needs that we see in academic libraries, consider the visualization of electronic resources, which become in a sense more tangible for the students who use only stacks-based browsing to locate items of relevance to their research. Librarians, educators, and publishers are faced with the challenge of providing access to digital content while still maintaining legacy print collections. The HoloBooks experiment will address access and use problems inherent in digital library collections of the networked era, including their highly disparate nature (many vended platforms serving licensed content) and their increasing intangibility (the move to massively electronic or e-only access in libraries and information centers). By developing a HoloBook reading experience, researchers will operationalize the transformation of digital-only content into print-like experiences and augment this mixed-reality experience with digital VR research support. Studies have shown that in some cases, reading comprehension may be lower on e-readers when compared to reading of nonfiction in print (Mangen & Kuiken, 2014). The proposed HoloBook project aims to provide contextual support for comprehension and learning. Researchers hypothesize that with VR reading, digital text will achieve a comprehension equivalent to print-based reading. By developing a unique HoloBook reading experience, librarians can provide integrated research support at the point of need. The current traditional reading experience does not allow opportunities for the integration of digital resources and research support—new HoloBook features and value-added services can support undergraduate students, especially as they go about completing research papers in their critical first years of study. HoloBook research support is responsive to students' contextual needs—since undergraduate student research in the digital era suffers from inadequate guideposts for knowing where to start, and students are seeking context when they begin research. This context is increasingly difficult to obtain in the online sphere (Head & Isenberg, 2009).

Statistical Visualization in Virtual Reality

Consider a VR use case that responds to the needs for data visualization and analytics within libraries. VR could help support visualizing assessment data. In academic libraries in particular, the need to support data analysis is great. It is not uncommon for researcher data to be derived from several different places—or in the data science terminology, data exists in silos within research organizations. Virtual exploration of data may help support the visualization from multiple disparate data sources and help decision makers explore data while at the same time help them to understand where gaps in their data-based decision making exist. Visualizing data is of course only one small component of data analysis—but it is a sector of the data enterprise that virtual reality could make more efficient, effective, and even more dynamic and enjoyable to explore. As an example from commerce, the start-up company CodeScience is at work developing an Oculus Rift VR app to visualize data from Salesforce (Rima, 2015). The Salesforce platform is a well-known customer relationship management tool. Therefore, a company with a Salesforce data API may likely be interested in quickly generating a picture of open leads, contracts, or client requests that may need attention.

Another example of the importance of VR for data visualization includes addressing the visualization of data with many dimensions. According to Donalek and colleagues, "The more dimensions we can visualize effectively, the higher are our chances of recognizing potentially interesting patterns, correlations, or outliers" (2014, p. 610). Using VR for data visualization would be particularly helpful in efforts to provide data curation where very large sets of data are curated by library professionals in collaboration with scientists. Researchers from Caltech also evaluated several tools for VR-based data visualization in the sciences and found that by employing VR headsets and common virtual world engines (like Second Life) that "these technologies give us a significant, cost-effective leveraging: their rapid development is paid for by the video gaming and other entertainment industries, and they are steadily becoming more powerful, more ubiquitous, and more affordable. They offer us an opportunity where any scientist can, with a minimal or no cost, have visual data exploration capabilities that are now provided by multi-million dollar cave-type installations, and with a portability of their laptops. Moreover, they open potentially novel ways of scientific interaction and collaboration" (Donalek et al. 2014, p. 613).

The notion of storytelling surfaces several times when discussing the capability of virtual reality. Telling stories with data would be a valuable use case for VR headsets. Consider the immersive possibilities of engaging with stakeholders by way of immersive data representations and findings. A compelling analysis of assessment and other types of learning data is an area ripe for innovation and piloting.

Makerspaces and Virtual Reality

Other considerations within libraries include integrating experimentation with VR experiences into makerspaces in libraries. Media creation and media development would find nice dovetails into virtual reality development. Students and faculty creating media may be interested in gaining experience in immersive storytelling.

One strand that deserves considering is the makerspace movement and its applicability to VR development, experimentation, and exposure to VR capabilities. According to the *NMC Horizon Report*, "Makerspaces are informal workshop environments located in community facilities or education institutions where people gather to create prototypes or products in a collaborative, do-it-yourself setting" (Johnson et al., 2016, p. 42). One can think of makerspaces as being areas by and for content creators—they are inhabited by people who are actively designing and crafting content or otherwise producing a tangible output of work. Makerspaces offer the promise to move academic institutions from places that primarily consume to places that are capable of design and production. These are the skills needed in the twenty-first-century workplace.

How will creative makers choose to engage in this medium? Creating and crafting video will be a part of this, to be sure. In the more traditional or classical conception of a makerspace, we might think of the space as being an area for video creation hobbyists. Extending from this video hobby, we might theorize that those with an interest in video creation and the 360 degree affordances that the VR headsets allow may be interested in the Jump Toolkit, which is intended to create 360 degree video viewed from within Google Cardboard (http://www.google.com/get/cardboard/jump/).

There are gaming development elements to VR as well, of course, those that blur the lines between narrative storytelling, illustration, and animation. It may certainly be the case that illustrators or those doing graphic design in makerspaces may help provide like-minded individuals with the space and materials for prototyping portions of VR experiences.

Developer Resources

Each of the VR headsets discussed above has a unique developer environment. As we previously noted while introducing the Google Cardboard SDK, software development can be a resource-intensive operation, which is also the case for virtual reality development. The following are SDKs and services to use when developing for each of the headsets described in this chapter:

- Oculus SDK is, at the time of this writing, in version 1.3. There is a helpful developer blog available at http://developer.oculus.com that periodically reports specific upgrades to the SDK and other developer-friendly assistance in creating applications for Oculus hardware.
- Due to the relative newness of the HTC Vive, its developer portal is just getting started with documentation and resources. There is the beginning of a portal here: https://www.htcvive.com/us/develop_portal, and an interesting open VR GitHub portal with some vendor-agnostic tools here: https://github.com/ValveSoftware/openvr/wiki/API-Documentation.

- Sony's PlayStation VR similarly does not yet have too much documentation on development resources for it. The Unity engine may be used in a variety of virtual reality systems and may be used for PlayStation VR development as well. Helpful developer documentation for the Unity engine is available here: https://unity3d.com/unity/multiplatform/vr-ar.

Sinclair and Gunhouse note that development work requires "a high-end desktop computer with fast processors and a good CPU. The software required includes a 3D modeler of some sort" (Sinclair & Gunhouse, 2016).

Compelling academic partnerships for VR development may exist for developing immersive experiences. Recent work in partnering with computer science faculty and students has led to innovative services and products that libraries are using in operations (Hahn, 2015). When undertaking these partnerships, there are some general themes to be aware of if engaging with undergraduate student coursework. These include being mindful of time constraints with student scheduling. Unlike full-time library developers, students will not be able to put in full days of work on an experiment project. However, they can contribute pieces or modules of functionality toward software development goals. So, while students are not professional developers, their prespecialization does come with certain advantages to a library makerspace for VR. The advantages to being prespecialized sometimes mean that the student does not understand the limitation of the domain—which can actually work to the advantage of those developing ideas; idea generation for virtual reality should incorporate student preferences and expectations for these environments. In this way, service uses can be built in early in the creation process of VR so that library-specific application is going to be useful for students and also respond to identified use cases.

Future Directions

This chapter is intended to bring the reader up to speed with several new areas of virtual reality and its applicability for teaching and learning in library settings. In order to stay up-to-date with VR technologies in the future, consider following these media outlets:

- *Wired* magazine is a long-running popular science and technology magazine that regularly reports on general-interest technology. Its focus on consumer electronics and popular culture makes it highly readable and relevant to up-and-coming trends within virtual reality in general. It is not library-specific, but it will help library leaders understand and track newer options in virtual reality as they become more generally available.
- The Verge (http://www.theverge.com) is a newer entrant (founded in 2011) in the news-tech field. It does provide several long-form reads

that treat technology news in depth, and provide additional deep understanding for newer consumer-facing products, similar to *Wired* magazine.

- The *New York Times* is increasingly covering cutting-edge technologies. As this chapter was being crafted, a helpful review of the Oculus was published (Chen, 2016).
- EWeek (http://www.eweek.com) is a shorter form roundup of quick news items. Its social media pages will help provide a snapshot of current virtual reality and other upcoming technologies. Usually, its posts include business-focused content—which can be useful for organizationally driven libraries in academic settings.

Each of the above-named technology organizations can be followed from its social media account, and their Twitter accounts are particularly useful to follow for timely updates on the continuing development of virtual reality. To dive deeper into academic-based research by computer scientists in mixed reality, consider following the ISMAR symposium (http://www.ismar.net). The international ISMAR symposiums have been the location for cutting-edge research in this domain since 2002.

Virtual reality consumer products offer new functionality for libraries, but they are also a largely untested technology. However, since the current wave of consumer VR products represents a profound advancement over previous iterations of head-mounted displays and previous virtual worlds, the trend should not be overlooked. Rather, librarians and academics may find that VR options can make possible teaching and research services that were previously unavailable, increasing students' engagement in libraries and higher education alike.

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