Immersion, Interactivity, and Virtual Reality

By Keith DeRuiter

Abstract:
Access to virtual reality is no longer a dream of the past. New technology and ideas have transformed it from science fiction into reality, and have opened up many opportunities and applications. Everything from entertainment to medicine stands to benefit from these advancements, and the developers of today have already started to make it happen.

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Virtual Reality: An Introduction

For many years, the idea of virtual reality and immersive technology seemed a far pitch speculated about in Hollywood and science fiction, or only available to advanced labs and scientists. With the advancement of computer and electronics technology over the last decade however, scientists and engineers have been able to make great leaps forward in making this futuristic technology a reality in everyday lives. But what is "Virtual Reality?" There is no standard definition, but the Merriam-Webster dictionary defines it as "an artificial world that consists of images and sounds created by a computer and that is affected by the actions of a person who is experiencing it" [1]. Two key components are presented here: a way to perceive the environment, and a way to effect change in or interact with the environment. Recent advancements in both of these areas are allowing normal people to experience virtual reality like never before, and leading to new applications in entertainment, medicine, and education.

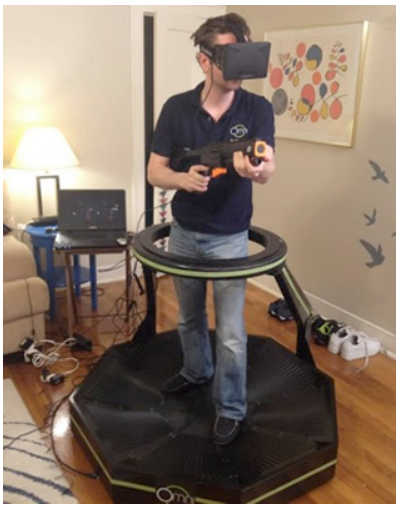
The Areas of Virtual Reality

Over the years, scientists have developed many different methods of perceiving and interacting with virtual environments we have created. The most important aspect of perception is generally visual, often through some kind of head mounted display (HMD). These typically work by having the wearer use a headset that displays two slightly different images to create the illusion of a 3D display. This technology is called stereoscopy [2], and while it has been around for a number of years, it has only more recently been effectively integrated into lower-cost display headsets. Combined with advancements in positional tracking using gyroscopes, accelerometers, and cameras, products exist that can monitor the position and orientation of a user's head, allowing them to look around a 3D virtual world.

One obstacle to these displays image fidelity. Having a display that close to your eyes requires a much higher resolution and refresh rate to feel natural [2]. New display technology has achieved this goal, leading to an experience that more closely mimics the feeling a wearer expects when looking around.

Equal advancements have been made in interaction that increase immersion for a user. Motion sensors that allow full tracking of controllers or armbands on each hand provide new levels of control. Products exist that can even sense electric pulses from the muscles in your arm to determine what gestures your hand is making. Force-feedback gloves and vests simulate the feeling of touching a real object or having force exerted of the wearer. All of these, combined with the display and perception methods mentioned above, are pushing towards the development of increasingly sophisticated virtual reality systems that have many applications.

VR in Our Daily Lives



One of the major areas of support for virtual reality has come form the gaming and entertainment community. These technologies open up possibilities in exploring exotic environments, piloting aircraft and spaceships, and simulating experiences otherwise outside our normal ability. Players can already experience scuba diving, piloting a moon lander, flying a jet, and many other scenarios through software being created by developers. Dedicated gamers have already set out developing mods (short for "modifications," small tweaks that add features to existing games) to adapt their favorite titles for VR support. This has generally included head mounted displays, but as the number of possible device accessories grows, so too have the adaptations been growing. Recent independent projects have taken sensors that track inertial measurements (acceleration and rotation) and mapped them to "joystick" functions in order to control a plane by moving your arms around.

Another application of these technologies in visualization comes from architecture. Virtual walkthroughs of houses and buildings before construction begins are being developed for use by designers and architects. They can use these kinds of systems to improve their plans, and catch problems early on by exploring their building and getting a sense for how it will feel and interact once constructed. With moves like this away from traditional human-computer interaction systems, and towards more dynamic, immersive interfaces, new ways of conveying information back to the computer have to be developed.

While using these systems, previously trivial tasks like typing a username into a form can now become cumbersome and awkward. How does one enter text while wearing a VR headset and potentially standing away from a keyboard? Solutions have ranged from small portable keypads, to dynamic typing interfaces controllable with your hands. Similar to how on smartphones, a keypad comes up when you are in a text-sensitive area, a virtual keyboard could appear on command through the VR display. A motion control device, or camera like the Kinect, would then be a suitable tool to read the user's movements and see where on the virtual keyboard they were typing. As more software and systems begin incorporating virtual reality in the future, new techniques like these will have to be developed and refined to ensure a smooth experience.

VR in Your Mind

Many of the most promising applications of virtual reality are in the field of medicine. One of the current applications of it involves treating victims of traumatic

events who suffer from Post Traumatic Stress Disorder (PTSD), especially members of the military returning from deployment. The Institute for Creative Technologies (ICT) here at USC is developing a system called Bravemind focusing on graduated exposure therapy to help treat the trauma [3]. Graduated exposure therapy is the process of slowly working with a patient through the events of their trauma, helping them handle the situation and overcome their stress [4]. This system allows therapists working with an individual to control the environment being explored and pace it according to the patient's progress. If their trauma came from a roadside bomb going off during a patrol on the outskirts of a town, their therapy can start with a convoy trip down a rural road in the countryside with no dramatic events. From there the clinician can progress to a trip in the desert, and slowly get closer to the actual events that the patient experienced to help them deal with it. This use of immersion has so far proved very effective in helping treat PTSD both here, and in other studies [3][5]. Virtual reality opens the door to new opportunities to improve the effectiveness of psychological treatments.

VR and Your Health

Virtual reality has also proved effective as a rehabilitation tool for individuals with other disabilities. Research is being done with amputees and those unable to walk on controlling prosthetic limbs through training in virtual reality [6]. In the real world, robotic devices and prosthetic arms assist these patients in movement. These devices work by measuring electric impulses from neurons, either near the affected area or from the brain directly. They then match these impulse patterns to the movements that the patient is trying to make happen. A prosthetic limb is then attached, and it's functions are controlled by the intended movements that were detected. The role of virtual reality in this case is to provide training for how to control these devices in a safe and controlled environment. Once the patient progresses far enough in the virtual world, they can begin to use the neural interface to control the real device and interact with the real world. One Brazilian teenager who is paralyzed from the waist down will even get to use this technology to deliver the opening kick of the 2014 FIFA World Cup [7].

The University of Washington and their burn center are also using virtual reality to help treat patients. Recent advancements in burn treatment have increased the rate of survival and speed of recovery. One problem that has not been addressed so far is the pain during treatment. While current drugs do an adequate job under normal circumstances, patients still reported excruciating levels of pain while having bandages

changed and undergoing other treatments [8]. The burn center is using virtual reality to help patients manage the pain, and has been relatively successful. The immersion of exploring a virtual world takes the patients' mind off of their pain, shifting their focus to the world presented to them instead of their trauma. This immersion here is key, since that is what takes the full concentration of the patient's mind, taking it away from their injury. The center has begun measuring its effectiveness of this procedure, and has found it to be very effective [8]. This success comes from just one of the growing number of medical facilities that are beginning to integrate virtual reality in new methods of patient care, and that number will only rise moving forward.

The Future

Within the past few years, many new companies and products have emerged targeting virtual reality. Oculus is pioneering affordable head mounted displays that should be available to the general public this year. New "Low-Persistence" OLEDs that make the display go dark for fractions of a second between images. This makes images appear less blurry by tricking our brain into seeing a smoother picture. Virtuix has developed an omni-directional treadmill that allows a user to walk and move around a full 360 degree range. This technology uses no moving parts, but rather a curved, low-friction surface and grooved shoes to facilitate normal motion detection while still letting the user stay in place. Facebook recently bought Oculus for 2 Billion dollars. This extra money and recognition is helping propel ideas about virtual reality and immersive technology from the world of developers and scientists into the spotlight for the general public. Imagine in the future where instead of coming home, checking your email, and getting updates on Facebook, you strap on a headset and can interact with your friends and family in a virtual holodeck-like experience! Instead of communicating over telephone or video call, we have interactive virtual 3D meeting rooms. These are still far off, but are quickly coming into reach. Researchers and developer have only just scratched the surface of what can be accomplished with virtual reality.

From medical treatments to video games, and scientific visualization tools to computer-based therapy, the applications of this technology are broad. With VR technology advancing at a rapid pace, all of these advancements have a common goal: increase the level of immersion and interactivity to provide a seamless experience for the user. Virtual reality is providing scientists and engineers one of the most versatile technologies available, proving itself as a foundational technology of the future.

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