A Survey: Augmented Reality and Virtual Reality

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Abstract

We are on the verge of reshaping existing ways of doing things ubiquitously, by adopting Augmented Reality (AR) which overlays digital information onto the physical world, or Virtual Reality (VR) which immerses the user in a virtual world. They will support us in fields such as education, maintenance, design and reconnaissance, to name but a few. This paper describes the field of both AR and VR, including a brief definition, evolution history that including the enabling technologies and their characteristics. Then, it surveys the state of the art by reviewing some recent applications as well as some known limitations regarding human factors in the use of augmented/virtual reality systems that developers will need to overcome.

Keywords: Augmented Reality, Virtual Reality, Opportunities, Challenges

1. Introduction

Augmented reality is one part of the general area of mixed reality[1]. It combines real and virtual objects in a real environment; registers (aligns) real and virtual objects with each other; and runs interactively in three dimensions and in real time. The physical/real-world environment is augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data[2]. It is related to a more general concept called mediated reality, in which a view of reality is modified (possibly even diminished rather than augmented) by a computer. Augmentation is conventionally in real-time and in semantic context with environmental elements, such as sports scores on TV during a match. With the help of advanced AR technology, the information about the surrounding real world of the user becomes interactive and digitally manipulable. Information about the environment and its objects is overlaid on the real world.

By contrast, virtual reality replaces the real world with a simulated one[3]. Virtual reality typically refers to computer technologies that use software to

generate realistic images, sounds and other sensations that replicate a real environment (or create an imaginary setting), and simulate a user's physical presence in this environment, by enabling the user to interact with this space and any objects depicted therein using specialized display screens or projectors and other devices. VR has been treated as a realistic and immersive simulation of a three-dimensional environment, created using interactive software and hardware. A person using virtual reality equipment is typically able to "look around" the artificial world, move about in it and interact with features or items that are depicted on a screen or in goggles. Virtual realities artificially create sensory experiences, which can include sight, touch, hearing, and, less commonly, smell.

(a) Oculus (b) Sony PlayStation (c) HTC Vive (d) Samsung Gear

Figure 1: Popular VR Hardwares

Virtual reality and augmented reality have different use cases, technologies, and market opportunities, so it's important to distinguish between the two. Virtual reality immerses a user in an imagined or replicated world (like videogames, movies, or flight simulation) or simulates presence in the real world (like watching a sporting event live). Example of hardware players in VR are Oculus, Sony PlayStation VR, HTC Vive, and Samsung Gear VR shown in Fig.1. Augmented reality overlays digital imagery onto real world. Examples of hardware players in AR are Microsoft HoloLens, Google Glass, and Magic Leap as shown in Fig.2. An easy way to differentiate between the two is that VR uses an opaque headset(which you cannot see through) to completely immerse the user in a virtual world whereas AR uses a clear headset so the users can see the real world and overlay infomation and imagery onto it.

While VR and AR can have different use cases, we view both technologies as driving the broader trend of HMDs as a computing form factor. Whether for consumer use or enterprise use, both VR and AR technology have the

Table 1: Comparison between AR and VR

	Augmented Reality	Virtual Reality
Attribute	Both Virtual and Reality	Virtual
Enviroment	Real (Physical)	Virtual
Scenarios	Demonstrations, Architechure, Designing	Video Games Related
Interactions	Move, Rotate, Scale and Manipulate the 3D object in real world	Move, Rotate and Scale 3D object in virtual world
Techniques	Display, Calibration, Tracking and Interaction	Same with AR

challenge of convincing the world that the value proposition is high enough to add another device to the current state of offerings in desktops, notebooks, tablets, and smartphones. Further, both VR and AR are gesture-based where the controls are largely driven by head and hand movements; while we view these gesture-based controls as intuitive this will serve as a new way to navigate the computing enviroment.

(a) HoloLens (b) Google Glass (c) Magic Leap

Figure 2: Popular AR Hardwares and solution

The rest of this survey is organised as follows: in Section 2, this survey will introduce the history of augmented reality and virtual reality; in Section 3, this paper will illustrate the supporting techniques; in the next section, this paper will show their industrial influences; in section 5 and 6, this paper

will analyse the opportunities and challenges of AR/VR. method and its local applications to both respiratory motion monitoring and ultrasonic image fusion. Finally, this paper gives briefly discussion and conclusion in Section 7.

2. Evolution

2.1. Brief History of AR

The first AR prototypes (Fig. 3), created by computer graphics pioneer Ivan Sutherland and his students at Harvard University and the University of Utah, appeared in the 1960s and used a see-through to present 3D graphics[4]. During the 1970s and 1980s, mobile devices were introduced. For decades, researchers are paving the way for wearable computing techniques until early 1990s the term "augmented reality" was proposed[5]. By the late 1990s, as AR became a distinct field of research, several conferences on AR began.

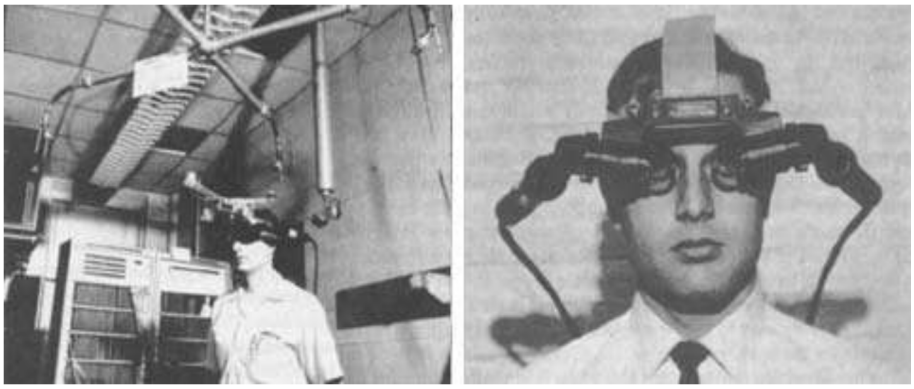


Figure 3: The world's first head-mounted display with the "Sword of Damocles"[4]

In the 21st century, augmented reality makes great progress. In 2000, Bruce H. Thomas develops ARQuake, the first outdoor mobile AR game, demonstrating it in the International Symposium on Wearable Computers. In 2004, Trimble Navigation and the Human Interface Technology Laboratory demostrated the Outdoor helmet-mounted AR system. In 2012, AR gaming platform Lyteshot was launched that could utilizes smartglasses for game data. In 2013, Google announces an open beta test of its Google Glass augmented reality glasses. In 2015, Microsoft announces Windows Holographic and the HoloLens augmented reality headset. The headset utilizes

various sensors and a processing unit to blend high definition "holograms" with the real world. Then, Niantic released Pokmon Go for iOS and Android in July 2016. The game quickly became one of the most used applications and has brought augmented reality to the mainstream.[6]

2.2. Brief History of VR

Virtual reality was first coined in 1987 by Jaron Lanier, founder of the visual programming lab where several VR devices like the Data Glove, the Eye Phone and the Audio Sphere were invented. In the 1990s, the public gradually had access to VR devices, although household ownership of cutting edge virtual reality was still far out of reach. The Virtuality Group launched a range of arcade games and machines. The Lawnmower Man movie introduced the concept of virtual reality to a wider audience. In 1995, Nintendo Virtual Boy (originally known as VR-32) was launched and it was be the first ever portable console that could display true 3D graphics.

The first fifteen years of the 21st century has seen major, rapid advancement in the development of virtual reality. Computer technology, especially small and powerful mobile technologies, have exploded while prices are constantly driven down. Recently Google have released interim virtual reality products such as the Google Cardboard. Samsung have taken this concept further with products such as the Galaxy Gear, which is mass produced and contains "smart" features such as gesture control. Developer versions of final consumer products have also been available for a few years, so there has been a steady stream of software projects creating content for the immanent market entrance of modern virtual reality.

It seems clear that 2016 will be a key year in the virtual reality industry. Multiple consumer devices that seem to finally answer the unfulfilled promises made by virtual reality in the 1990s will come to market at that time. These include the pioneering Oculus Rift, which was purchased by social media giant Facebook in 2014 for the staggering sum of $2BN. An incredible vote of confidence in where the industry is set to go. When the Oculus Rift releases in 2016 it will be competing with products from Valve corporation and HTC, Microsoft as well as Sony Computer Entertainment. These heavyweights are sure to be followed by many other enterprises, should the market take off as expected.

3. Applications & Industry

3.1. Create New Markets

Some advanced haptic systems in the 2010s now include tactile information, generally known as force feedback in medical, video gaming and military training applications. Some VR systems used in video games can transmit vibrations and other sensations to the user via the game controller. Virtual reality also refers to remote communication environments which provide a virtual presence of users with through telepresence and telexistence or the use of a virtual artifact (VA), either through the use of standard input devices such as a keyboard and mouse, or through multimodal devices such as a wired glove or omnidirectional treadmills. The immersive environment can be similar to the real world in order to create a lifelike experiencefor example, in simulations for pilot or combat training, which depict realistic images and sounds of the world, where the normal laws of physics apply (e.g., in flight simulators), or it can differ significantly from reality, such as in VR video games that take place in fantasy settings, where gamers can use fictional magic and telekinesis powers.

3.2. Reform Old Industries

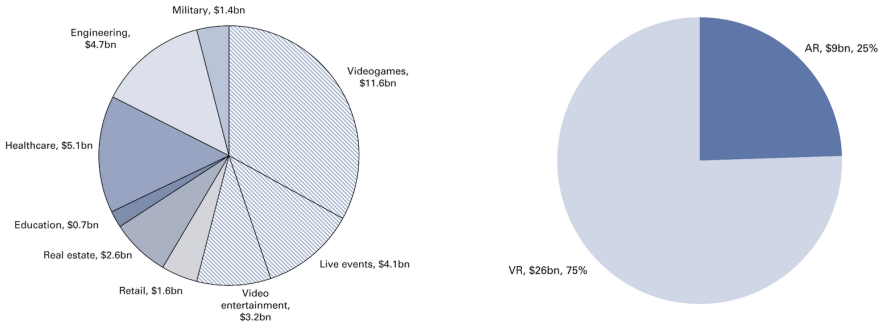
Both AR and VR have the potential to not only create new markets but also disrupt existing ones. Nine cases for AR/VR technology are emerging: videogames, live events, video entertainment, retail, real estate, education, healthcare, engineer, and military (Fig.4).

According to the prediction from GoldmanSach 2016, videogames, live events, and video entertainment are the only 3 cases that are entirely driven by the consumer and make up 60% of total AR/VR revenue assumptions for 2025. The remaining 40% is driving by enterprise and public sector spend with the largest revenue generating use cases in engineering, healthcare, and real estate. Some use cases are specific to VR, some use cases are specific to AR, and some cases overlap. The report indicates that AR technology still needs to mature, especially in display technology and the real-time processing and calibration of real-world physical enviroment. As AR technology matures, we see stronger enterprise use cases emergeing especially considering AR enables you to see your physical environment whereas VR completely blocks it.

(a) Education and training (b) Entertainment (c) Medical Application (d) Manufacturing

(e) Tourism (f) Collaboration (g) Design (h) Navigation

Figure 4: Popular applications of AR or VR



(a) (b)

Figure 5: (a)Consumer-driven use cases in videogames, live events and video driving 60% of software spend with the remainder from enterprise and public sector; (b)VR use cases driving 75% of our software estimate; as AR technology matures we expect more enterprise use cases to emerge

4. Challenges

4.1. The Limitations of Augmented Reality

AR faces technical challenges regarding for example binocular (stereo) view, high resolution, colour depth, luminance, contrast, field of view, and focus depth. However, before AR becomes accepted as part of user's everyday life, just like mobile phones and personal digital assistants (PDAs), issues regarding intuitive interfaces, costs, weight, power usage, ergonomics, and appearance must also be addressed. A number of limitations, some of which have been mentioned earlier, are categorised here.

Aside from technical challenges, the user interface must also follow some guidelines as not to overload the user with information while also preventing the user to overly rely on the AR system such that important cues from the environment are missed[7]. At BMW, Bengler and Passaro use guidelines for AR system design in cars, including orientation on the driving task, no moving or obstructing imagery, add only information that improves driving performance, avoid side effects like tunnel vision and cognitive capture, and only use information that does not distract, intrude or disturb given different situations.

Getting people to use AR may be more challenging than expected, and many factors play a role in social acceptance of AR ranging from unobtrusive fashionable appearance (gloves, helmets, etc.) to privacy concerns. These fundamental issues must be addressed before AR is widely accepted[8].

4.2. The Limitations of Virtual Reality

There are certain health and safety considerations of virtual reality. For example, a number of unwanted symptoms have been caused by prolonged use of virtual reality,[9] and these may have slowed proliferation of the technology. Most virtual reality systems come with consumer warnings. Virtual reality sickness (also known as cybersickness) occurs when a person's exposure to a virtual environment causes symptoms that are similar to motion sickness symptoms.[10] The most common symptoms are general discomfort, headache, stomach awareness, nausea, vomiting, pallor, sweating, fatigue, drowsiness, disorientation, and apathy.[11] Other symptoms include postural instability and retching.

In addition, there are social and philosophical considerations and implications associated with the use of virtual reality. There has been an increase in interest in the potential social impact of new technologies, such as virtual

reality. Mychilo S. Cline's book Power, Madness, and Immortality: The Future of Virtual Reality, argues that virtual reality will lead to a number of important changes in human life and activity.[12] He argues that virtual reality will be integrated into daily life and activity, and will be used in various human ways. Another such speculation has been written up on how to reach ultimate happiness via virtual reality.[13] He also argues that techniques will be developed to influence human behavior, interpersonal communication, and cognition. As we spend more and more time in virtual space, there would be a gradual "migration to virtual space", resulting in important changes in economics, worldview, and culture.

Virtual reality technology faces a number of challenges, most of which involve motion sickness and technical matters. Users might become disoriented in a purely virtual environment, causing balance issues; computer latency might affect the simulation, providing a less-than-satisfactory user experience; the complicated nature of head-mounted displays and input systems such as specialized gloves and boots may require specialized training to operate, and navigating the non-virtual environment (if the user is not confined to a limited area) might prove dangerous without external sensory information. There are areas of VR that need solutions, such as 3D audio, haptics, body tracking, and input. However, 3D audio effects exist in games and simulate the head-related transfer function of the listener (especially using headphones). There have been rising concerns that with the advent of virtual reality, some users may experience virtual reality addiction.

5. Discuss & Conclusion

Fundamentally, virtual/augmented reality creates a new and even more intuitive way to interact with a computer. In the world of virtual/augmented reality, the controls of the computer become what we are already familiar with through gestures and graphics. VR/AR also gives us wider field of view, where the concept of virtual desktop is no longer confined by the size of a physical display screen on our desktop or in the palm of our hands. Given this attribute of ease of use and the multiple use cases across VR/AR, we see the potential for technology to emerge from vertical specific use cases to a broader computing platform. Meanwhile, virtual/augmented reality faces a bunch of challenges, including not only technical problems, but nontechnical problems such as social acceptance, health considerations and even philosophical issues.

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