VR Technology: Development Status and Typical Applications in Industry

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Abstract. Virtual Reality (VR) technology is new technology in the computer field developed as a combination of computer graphics technology, multimedia technology, sensor technology, human-computer interaction technology, network technology, three-dimensional display technology, simulation technology and other science and technology. It can provide users with a set of visual, auditory, tactile simulation of a 3D virtual environment. It has been applied in social entertainment, industrial design and manufacturing, virtual evaluation and many other aspects from the initial field of computer graphics. VR technology has developed rapidly in recent years and has been widely used in industrial field.

Keywords: Virtual Reality, Computer Graphics Technology, Human-Computer Interaction, Three-Dimensional Virtual Environment.

1. Introduction

VR technology is originated from the military activities within the US military and gradually became a technology accepted and used by all walks of life, which is a masterpiece with integration of computer technology, computer graphics technology, multimedia technology, simulation technology, visual reality technology, sensor technology, ergonomics, human-computer interaction technology, artificial intelligence, software engineering and many other high-end technologies. And it is a computer technology that creates an experiential virtual world. It gives users a 3D virtual world in which they can engage in dialogue with one or more subjects in a simulated way. In addition, users can observe and interact with objects in a 3D virtual world through head-mounted display (HMD), naked hand (data glove) or non-naked hand (handle) sensing and interactive devices. With the development of science and technology, the simulation of the senses expands from vision and hearing to five senses including touch, smell and taste, so that users can have a better immersion experience.

With the development and popularization of VR technology, it is actually a new way for human beings to behave differently from the traditional approach based on reality. Different from traditional methods, VR technology can make people work with computers and various jobs based on computer technology more convenient and humanized. It provides a contemporary design and review method for engineering projects, and provides a more intuitive visual description method for a large number of data and its actual effects in the project. VR technology is not only applied in industry, but also widely used in military, aerospace, medical treatment, education, entertainment, social contact, etc., providing people with a new way of life and work.

VR technology has many advantages, such as high efficiency, controllability, safety, no influence from reality, and no limitation from weather and field. Now it is commonly used in all fields of industry. This paper will be focused on the development status of VR technology, its typical application in the industrial field and its development trend.

2. VR Technology and Its System

VR technology is the product of a variety of technologies, including real-time 3D computer graphics, virtual scene reality technology, real-time tracking and feedback technology in software. In terms of hardware, there are head-mounted display and eye-tracking technology, haptic feedback technology in data gloves and gesture tracking technology. Typical VR system is generally composed of computers, input/output devices, application software and database. The detailed functions of each component are as follows:

2.1 Computer

Computer is the core component of VR system, and it is the carrier of VR application software. It is responsible for the composition of virtual 3D world and human-computer interaction and feedback between human and virtual world. Compared with the traditional human-computer interaction model based on screen, mouse and keyboard, VR technology requires more computing power and image display ability of computers to guarantee more complex virtual environment and more flexible interaction. This also puts forward the high requirements to the computer hardware ability.

2.2 Input/Output Device

2.2.1 Data Gloves

As an important interactive device in the VR system, data gloves are a typical VR system input device. It can be divided into VR data gloves and force feedback data gloves according to functional requirements. VR data gloves can grasp and move virtual objects through software programming. Current products can detect the bend of fingers and use magnetic positioning sensors to accurately locate the position of the hand in three-dimensional space. Force feedback data gloves can provide users with tactile feedback from the virtual world, so that users can feel the touch of real objects when interacting with the virtual environment built by the computer and get more flexible immersion experience.

2.2.2 Head-Mounted Display

VR head-mounted display device, or VR head display device for short, is a typical VR system output device. It generally includes external head display device, integrated head display device and so on. VR head display closes the user's vision and hearing from the outside world, providing an immersive visual and auditory experience. At the same time, VR head display device also has the function of capturing the user's head rotation and eye rotation, providing users with real-time perspective and image changes. Existing VR devices are not very good at visual presentation. At present, the mainstream VR head display device products include SONY's play station VR, HTC's VIVE and so on.

2.3 Application Software

Nowadays, the software development of VR technology is based on a variety of development software, such as VRMagic [1]. The platform adopts modular design, and the modules communicate with each other through a unified data structure. The 3D virtual studio subsystem based on WTK is the core module of the platform. It generates virtual scene by analyzing simulation description file, with six degrees of freedom roaming, real-time interaction, real-time video composite GIF animation and other functions. It also supports 3D glasses, V8 helmet, and Cyber Glove data gloves with multiple positioning and tracking devices.

2.4 Database

Database is a warehouse built on computer storage equipment to organize, store and manage data according to the data structure in a VR system. Simply it can be viewed as an electronic filing cabinet, that is, a place to store electronic files. Users can add, intercept, update, and delete the data in the file. The database provides data support for virtual world composition in VR technology [2].

According to the overall structure of the VR system, as well as the degree of user participation and immersion, VR system can be divided into desktop VR system, immersion VR system and distributed VR system.

(1) Desktop VR system: this system is a small virtual reality system based on a PC platform of the personal computer. It uses PC graphics workstation and stereoscopic display to work, and users use interactive devices such as data gloves to experience the virtual world. Although it lacks a complete immersion experience, it requires less for hardware and costs less, and is generally applicable to researcher just entering virtual reality.

(2) Immersive VR system: compared with the former, this system is more powerful in hardware. It utilizes virtual reality head-mounted display device to close users' vision and hearing from the outside world. Data gloves provide the user with a sense of touch when interacting with virtual objects. Immersive VR system makes use of the corresponding head tracker, eye tracker and hand tracker to make the system more real-time and bring immersion interactive experience to users.

(3) Distributed VR system: this system is an internet-based VR system that enables users in different geographical locations to connect with their virtual world. It enables multiple users to enter the same virtual world at the same time. Users and virtual environment, and users and users can get real-time interaction and mutual influence.

3. Development Status at Home and Abroad

3.1 Foreign Development Status

Research on VR technology started earlier abroad, especially in the United States, Japan, Germany and other countries. Its main research direction focuses on human-computer interaction, software and hardware basic platform research and development. As is known to all, the United States leads the world in VR technology research. Typical researches include:

(1) Ames laboratory in NASA: it engineered data gloves to be a highly usable product and completed real-time simulation of space station manipulation at the Johnson space center.

(2) SRI research center established the "visual perception program" to study the further development of existing VR technology. After 1991, SRI conducted training and research on military aircraft or vehicle driving with VR technology, trying to reduce flight accidents through simulation [4].

(3) In the 2017 MIT Sloan research award for healthcare innovation, Rendever developed a VR platform that can help elderly people living in nursing homes explore the virtual world. The platform also provides cognitive therapy and exercise tracking data that can help in the early diagnosis of Alzheimer's disease.

(4) The US military has been using VR technology in its military since the 1990s [5]. For example, during the peacekeeping operation in Bosnia and Herzegovina in the autumn of 1995, before the US military prepared to bomb the Yugoslavia, VR technology was used to make virtual military maps of 80% of the terrain in Bosnia and Herzegovina.

In addition, Japan also plays an important role in VR technology research and development, and its development of the virtual games is at the forefront of the world. Some of the more typical studies are:

(1) The Japanese company BIPSEE has developed a set of equipment called "BIPSEE dental VR", which can cut patients' vision from the outside world and provide patients with pictures that can relieve tension and pain. It also allows the patient's sub-consciousness to make gestures conducive to therapy.

(2) Japanese company wacom has developed a 3D model VR pen, which enables users to transform the graphics drawn in 2D space into 3D space models. It is faster and more efficient than traditional drawing methods in engineering design and other fields.

(3) Japanese company Holoeyes used CT scan images to build a VR model of the patient's organ, so that surgeons can more intuitively analyze and discuss the patient's condition and operation.

(4) SONY entertainment’s gaming department, has launched several game products based on play station VR games in recent years, aimed at creating a more impressive gaming experience for gamers.

In addition to the United States and Japan, other western countries also use VR technology in many fields, such as:

Tribemix and Quantum Care, two British companies that design VirtuCare, use VR technology to reconstruct the past in a virtual world to help elderly people with cognitive impairment to restore memory.

3.2 Domestic Development Status

Compared with the western countries, the development of virtual reality technology in China started relatively late. China started the research and application of VR technology in the 1990s, but due to the limited national strength and technology at that time, VR technology was mainly concentrated in the military field. At present, we are still in the initial stage of VR technology research and application. The main research focuses on universities and research institutes, as well as major technology companies. Its research results are more used in consumption fields, such as games, film and television, real estate sales. However, the VR industry in China has developed rapidly in recent years. As the hardware update speed of computer and VR equipment slows down and software programming technology becomes more and more popular, so that VR technology and its related industries can develop rapidly in China.

As for the achievements of VR technology in China at the present stage, in terms of software, for example, Alibaba launched a new shopping mode Buy+. It uses computer graphics system and auxiliary sensors to generate an interactive three-dimensional shopping environment, so that consumers have a more comprehensive understanding of commercial goods. Hardware: 3Glasses introduced VR head display device "Blubur S1 experience version". Its resolution is nearly double that of the previous product's single screen 2K, and no lattice sense has been detected, which can significantly reduce the sense of dizziness. Meanwhile, many VR experience stores have been built-in major cities in China. According to statistics, in 2016 alone, 35,000 VR experience stores were opened in China, enabling more ordinary people to access and experience VR technology.

However, there are still many problems in the development of VR technology in China, as detailed below:

(1) At present, VR technology in China is still dominated by replication and lacks innovation in hardware equipment and software platform.

(2) China's hardware standards have not yet been unified, and all content producers have no way to produce its content according to the unified standards. This makes it difficult for VR technology in China to form a complete ecological industrial chain.

(3) Chinese companies engaged in VR technology face the problem of lack of user resources and difficulty in forming a capital chain. Compared with Facebook, Samsung, SONY and other industry giants, these new companies need core competitiveness (i.e., immersive experience of VR technology) to develop. However, the technical research and publicity costs they need are difficult for them to support, thus entering a dead cycle.

At present, large enterprises with capital are still required to take the lead in the cooperation of VR technology in China to promote a complete industrial chain of VR technology to promote the development of VR technology.

In conclusion, although VR technology is now gradually developing and maturing, it has not been fully accepted by the public. There are still many problems and difficulties to be solved, which can be mainly expressed as the following two points:

(1) Hardware bottleneck. VR technology has high requirements for computers and input/output devices. For computing and image display capabilities of computers, companies led by Intel and Nvidia are still introducing more powerful CPU and graphics cards to meet the needs of VR. However, the latest technology products can only be used in research institutions and enterprises due to their high prices, and cannot be used in thousands of households. Take Nvidia's latest RTX2080Ti graphics card as an example, the price of ten thousand yuan does not make it popular. For input and output devices, VR head display is the main feature, and the existing imaging technology is still unable to solve the dizziness of some users in the virtual 3D world. At present, VR mainly provides users with visual, auditory and tactile experience. However, in the taste and smell, and even all the sensory immersive experience of the whole body, it still needs to upgrade the hardware.

(2) Limitations of the application field. Take Germany, where VR technology is very developed, as an example, every six German citizens (16%) have tried VR with their friends at exhibitions or museums. Eight percent of people already own VR glasses. VR users mainly focus on game experience (72%), virtual travel (43%) or movie (38%). A quarter of people plan their homes in virtual

rooms (26%) to visualize their homes. One sixth people use VR glasses during exercise (17%). It also has gained 8% VR experience in education and learning projects. Commercial VR technology applications are still mainly focused on games and other entertainment, and VR technology needs greater promotion and support to be applied in more aspects.

4. Typical Applications of VR Technology in Industrial Field

VR technology has been widely used in the industrial field. In addition to itself, VR technology is often used together with augmented reality (AR) technology. The following examples are expounded.

(1) Siemens has a project called “Cave”, which is based on hybrid reality (VR and AR) technology. In Cave's environment, images and physical settings of real objects are reproduced and projected as virtual images onto the walls of a real room. And it’s hardware mainly contains three-sided projection wall, ground projection floor, wall tracking sensor. It uses three walls to form a stereo. Among them, the projection wall and stereo provide users with a virtual world based on reality. Cave walls have tracking sensors that capture a user's movements inside a room. Special glasses create images based on the actions captured, allowing users to interact with the virtual world. The project is being run by 100 companies in Germany. Audi has created a technology called “virtual assembly line verification” based on CAVE, in which assembly-line workers use data gloves. It completes the assembly of actual products in the 3D virtual world, so that it can complete the estimation and calibration of the real assembly work. This technology can discover and solve the possible problems in the assembly process in advance in the virtual world before the production line is started. At the same time, it can also play the function of comparison and calibration in the assembly process, which greatly saves the cost.

The technology is not only used in the assembly of automobiles, but also in the whole manufacturing industry in the future.

(2) Bell, an American aircraft manufacturer, cooperated with HTC to design the company's first "concept helicopter" FCX-001 in only 6 months using VR technology, which shortens the design time of the helicopter by about 10 times. The company works with 5 digitals, a division specializing in 3D design and production. The original design and model are generated in CAD and then converted to Unity. With the HTC Vive, engineers can test complete virtual models in a virtual world without having to build physical models. They can also modify virtual models directly without having to make new physical models. This makes the design process easier and saves a lot of time and money before creating a physical prototype. Bell says virtual reality could save the company millions or even tens of millions of dollars compared to traditional design process.

5. Development Trend of VR Technology

Throughout the development of virtual reality technology over the past 30 years, the future research of VR technology still follows the main line of “low cost and high performance”. From the perspective of the development level of technology, there are the following main development directions:

5.1 Comprehensiveness

VR technology has been applied in military, industry, medical treatment, education, entertainment, social contact and other aspects, but there are still many aspects that VR technology has not yet been involved in. With its development, it is bound to play its role in more aspects.

5.2 Popularization

VR technology is still not accepted by the general public due to its high requirements for hardware and software. With the development and popularization of hardware, VR technology should be similar to smart phones and other technologies in terms of price, increase production of equipment and software, and gain a larger audience.

5.3 High-End Immersion

At present, the immersive experience provided by VR devices is still incomplete, and users can still feel the sense of smell and touch in the real world. The development direction of VR technology should be to build a virtual world that can completely block the user's sensory connection with reality and enable the user to place every sensation in it. Moreover, the interaction between the two needs to be improved to provide a completely virtual sense of reality.

6. Conclusion

Currently, VR technology is booming and effectively applied in industry, military, medical treatment, education and other aspects. With the continuous development of this technology, the publicity of VR technology by the public media and the impact of VR technology on traditional ways in all walks of life will bound to make it better accept VR technology and actively explore ways to apply VR technology. The future will be dominated by VR technology.

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