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Research on Human Computer Interaction Technology in Virtual Reality Scenes

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Abstract: This paper discusses the current status, challenges and development trends of human computer interaction technology in virtual reality scenarios. Virtual reality technology has gradually become a frontier field of human computer interaction research. This paper analyzes virtual reality technology and human computer interaction technology. By introducing the commonly used human computer interaction hardware equipment and software technology in current virtual reality scenarios, it reveals the actual application of human computer interaction in virtual reality environments. From the three aspects of technology, user experience, and security and privacy protection, this paper analyzes the challenges faced by human computer interaction technology in virtual reality scenarios. In the future, with the continuous advancement of technological innovation, new human-computer interaction technologies will continue to emerge, and the integration of artificial intelligence technology will further enhance the intelligence level of human-computer interaction, making the user interaction experience more natural and convenient.

Keywords: Virtual Reality Technology; Virtual Scenes; Human Computer Interaction; Technological Innovation.

1. Introduction

Since its birth, virtual reality technology has attracted the attention of many researchers and developers with its unique charm. With the improvement of computing power and the maturity of 3D modeling technology, VR technology has gradually moved from theoretical exploration to practical application and has shown great potential in many fields. In many fields such as military, education, medical, construction, entertainment and industrial manufacturing, the application of VR technology has brought revolutionary changes to related industries. In order to truly realize the potential of VR technology, the research and development of human computer interaction technology is particularly important. Since the invention of the world's first computer ENIAC, human computer interaction has become a very important branch of computer science[1].In a virtual environment, users expect to have perceptions and experiences similar to those in the real world, which requires human computer interaction technology to be highly natural and efficient. Through the comprehensive application of technologies such as gesture recognition, voice control, and eye tracking, users can interact with the virtual environment in a more natural and intuitive way, thereby obtaining a more realistic and immersive experience.

In recent years, the research and application of human computer interaction technology in virtual reality scenarios has made a series of important progress. Accurate gesture recognition technology enables users to control the virtual environment through hand movements, while realistic tactile feedback technology brings users a more realistic touch experience. Rich sound rendering technology also creates a more three dimensional auditory environment for users. The comprehensive application of these technologies has greatly enhanced the realism and immersion of the VR experience, making users feel as if they are in a brand new virtual world [2]. Although technology continues to advance, human computer interaction technology still faces many problems in VR scenarios. First, the technology itself has certain limitations, such as the accuracy of gesture recognition and voice recognition, which still need to be improved. Second, user adaptation and interaction habits are also important factors affecting the VR experience.

With the continuous advancement of technologies such as artificial intelligence and big data, human computer interaction technology is expected to achieve a more intelligent and personalized interaction method. Through technical means such as deep learning and natural language processing, human-computer interaction systems can more accurately understand users' intentions and needs, thereby providing more intelligent and personalized services.

2. Virtual Reality and Human Computer Interaction Technology

2.1. Virtual Reality Technology

Virtual reality technology is a computer technology that can simulate, create and experience a virtual world. It enables users to be fully immersed in a three dimensional environment generated by a computer through advanced human-computer interaction devices such as head-mounted displays, gloves, motion capture devices, etc. The main application areas of virtual reality technology are very wide. In the field of game entertainment, VR technology provides players with a more realistic and immersive gaming experience; in the field of education and training, VR technology can simulate various complex environments and provide learners with intuitive and vivid learning materials; in the medical field, VR technology can be used for surgical simulation, rehabilitation training, etc. to improve medical efficiency and effectiveness [3]; in addition, in the fields of real estate, tourism, military, etc., VR technology has also shown great application potential.

2.2. Human Computer Interaction Technology

Human Computer Interaction (HCI) is a discipline that

studies the interaction between humans and computer systems. It involves multiple fields such as computer system design, psychology, cognitive science, and industrial design.

The development of HCI technology can be roughly divided into four stages:

(1) Early stage (1940s-1960s): Human computer interaction mainly relies on command line interface (CLI) and batch processing system. Users need to interact with computers by entering specific commands. This interaction method requires users to have certain computer expertise. For non-professional users, the threshold for use is relatively high.

(2) Graphical user interface stage (1960s-1980s): Graphical user interface (GUI) began to become popular. GUI enables users to interact with computers in a more intuitive and natural way through intuitive graphic elements and input devices such as mouse and keyboard. During this period, the development of operating systems such as Windows and Mac OS greatly promoted the advancement of HCI technology [4].

(3) Multimedia and touch screen stage (1980s-2010s): With the development of multimedia technology and touch screen technology, users can interact with computers through voice, gestures, touch and other methods. The popularity of mobile devices such as smartphones and tablets has made human computer interaction technology closer to people's daily lives.

(4) Virtual reality and augmented reality stage (2010s to present): Virtual reality (VR) and augmented reality (AR) technologies have brought human computer interaction technology into a new stage. VR and AR technologies can provide users with a more immersive interactive experience, allowing users to be in a virtual or augmented environment and interact with virtual objects in it.

2.3. Application of Interactive Technology in Reality

(1) Touch screen technology: On mobile phones, tablet computers, self service terminals and other devices, users interact with the device by touching the screen to perform operations such as clicking, sliding, and zooming. Touch screen technology has greatly improved the usability and user experience of the device.

(2) Voice recognition technology: Voice recognition technology converts the user's voice instructions into text or commands to achieve interaction with the computer. This technology is widely used in smart home, smart customer service and other fields. For example, Siri, Xiao du speakers and other products provide information query services to users through voice recognition technology.

(3) Image recognition technology: Image recognition technology recognizes objects in the image and then classifies and identifies the objects. For example, it helps users automatically focus and adjust exposure when taking photos with a mobile phone; in the field of security monitoring, it realizes functions such as face recognition and license plate recognition.

(4) Virtual reality technology: Virtual reality technology simulates a three-dimensional environment to enable users to interact with the virtual world. Virtual reality technology has a wide range of applications in game entertainment, education and training, medical rehabilitation and other fields.

(5) Smart home technology: Connect various devices in the home through the Internet of Things technology to achieve interconnection and intelligent control between devices. Users interact with smart home systems through mobile phones, tablets and other devices to achieve remote control, timer switches, scene settings and other functions.

Human computer interaction technology has a wide range of applications in real life. It not only improves the usability and efficiency of computer systems, but also brings users a more natural, efficient and pleasant interactive experience. With the continuous advancement and development of science and technology, human computer interaction technology will play a more important role in future life.

3. Current Status of Virtual Reality Scene Interaction Technology

3.1. Hardware Equipment

In virtual reality scenarios, commonly used human computer interaction hardware devices are:

(1) VR Headset: The virtual reality helmet is the main interface for users to enter the virtual world. It covers the user's eyes through two high-definition display screens to present a three-dimensional virtual scene. Common virtual reality helmets include Oculus Rift, HTC Vive, PlayStation VR, etc.

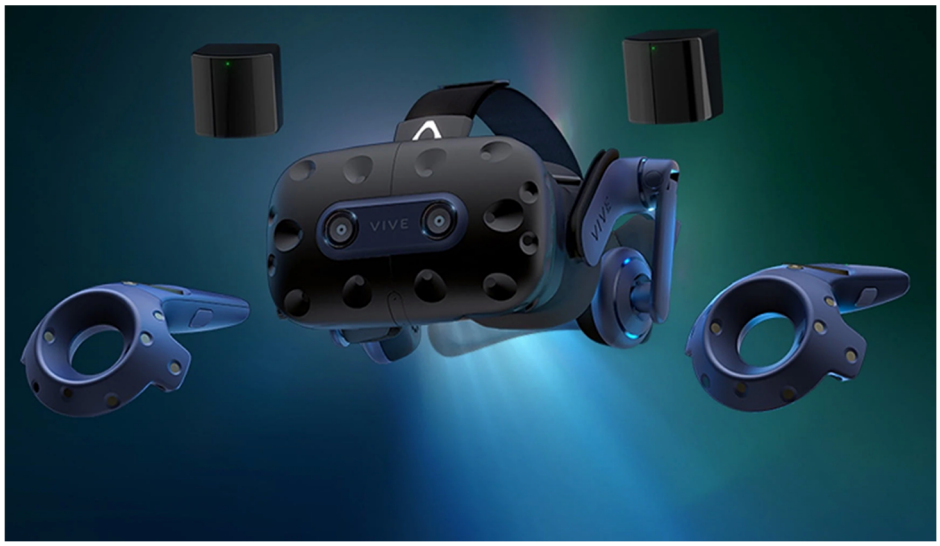

Fig 1. VIVE Pro 2 (https://www.vive.com/cn)

(2) VR Controller: VR Controller allows users to interact with objects in the virtual world in a more natural and

intuitive way. They are usually equipped with multiple buttons, joysticks and touchpads that can simulate the user's hand movements and gestures. For example, the controllers of Oculus Touch and HTC Vive can track the user's hand position and movements and provide tactile feedback, allowing users to feel the texture and weight of virtual objects.

(3) Sensors: In virtual reality scenarios, sensors are the key to achieving accurate interaction. They can monitor the user's body movements, position, direction and other information in real time and transmit it to the computer system for processing. Common sensors include accelerometers, gyroscopes, magnetometers, etc.

(4) In addition to the above main devices, there are also some human computer interaction hardware devices that can further enhance the virtual reality experience. For example, eye tracking devices can track the user's eye movements in real time; tactile feedback devices can simulate the touch of virtual objects through vibration, electric current, etc.; motion capture devices can capture the user's full body movements and map them to the virtual character.

3.2. Software Technology

In virtual reality (VR) scenarios, key software technologies for human computer interaction provide users with a natural, intuitive, and immersive interactive experience with the virtual world. The following are several key software technologies:

(1) 3D modeling: 3D modeling technology is the basis for building VR scenarios. Professional modeling software, such as 3DS MAX and CAD, can be used to create realistic virtual environments, characters, and objects.

(2) Motion capture: Motion capture technology can track the user's body movements in real time and feed them back to the virtual environment. With the help of a high precision motion capture system, users can interact with the virtual environment in a natural way, such as walking, jumping, raising their hands, etc., thereby enhancing the sense of immersion [5].

(3) Speech recognition: Speech recognition technology brings a new way of interaction to VR technology. Users can interact with the virtual environment through verbal commands. In VR scenarios, speech recognition technology can enhance immersion and realism, improve interaction and collaboration capabilities, and expand application scenarios and uses.

Key software technologies such as 3D modeling, motion capture, and speech recognition play an indispensable role in realizing human computer interaction in VR scenarios. The development and improvement of these technologies will further promote the application and popularization of VR technology and bring users a more natural, intuitive, and immersive experience.

3.3. Interactive Application Cases

In virtual reality (VR) scenarios, the application of human computer interaction technology has achieved remarkable results, bringing a new experience to users. The following are application cases showing the practical application of human computer interaction technology in virtual reality scenarios:

(1) Medical surgery simulation and training: Doctors can use VR helmets and handles for surgical simulation training without practicing on real patients. For example, the HaptX glove VR smart glove transmits gas through more than 300 tiny air bubbles to simulate real touch, allowing doctors to feel the pressure, temperature and texture during surgery. This simulation training reduces medical risks and improves surgical efficiency.

Fig 2. HTC VIVE ×V R First Aid Training(https://www.vive.com/cn)

(2) Education and training: In the field of education, students can use VR helmets to enter the scene of historical events, such as the battlefields of World War II, for immersive learning. VR technology can also simulate complex scientific experiments and dissection processes, allowing students to perform practical operations in a virtual environment and deepen their understanding of theoretical knowledge.

Fig 3. HTC VIVE × BAA Training (helps pilot training https://www.vive.com/cn)

(3) Corporate training and collaboration: In the field of corporate training, employees simulate real work scenarios in a virtual environment, such as mechanical maintenance and customer service, and improve their skills through practice. VR technology also supports remote collaboration, and employees in different locations can enter a virtual conference room together for real-time communication and collaboration.

(4) Game entertainment: Virtual reality game players put on VR helmets and controllers, enter the game world, interact with virtual characters, and experience immersive adventure and excitement. For example, some VR games support full body motion capture, and players can control game characters through body movements to achieve a more natural and realistic gaming experience.

(5) Real estate and architectural design: Customers can roam in virtual houses or buildings through VR helmets and experience different spatial layouts and decoration styles. Designers can also make real-time modifications and adjustments through VR technology to improve design efficiency and customer satisfaction.

4. Challenges of Human-Computer Interaction Technology in Virtual Reality Scenes

4.1. Technical Challenges

As the impact of intelligent machines on society continues to deepen, the question of whether intelligent machines in the future can control people has triggered thinking [6]. The diversity of technologies complicates achieving unified, efficient human computer interaction. Different devices, platforms and software may use different interaction methods and standards, which requires users to have a variety of interaction skills, increasing learning costs and difficulty of use. Although technologies such as speech recognition and gesture recognition have made significant progress, the accuracy and reliability of these technologies still need to be improved in complex environments. In addition, non verbal elements in human communication, such as facial expressions, body language, etc., are currently difficult to be fully understood and processed by computer systems. Although technologies such as machine learning have been widely used in human computer interaction, it is still difficult for computer systems to be as flexible and creative as humans.

4.2. User Experience Challenges

Improve the user experience of human computer interaction in virtual reality scenes and reduce operational complexity and cognitive load. First, simplifying interaction design is key. Designers need to deeply understand user needs and habits through intuitive and natural interaction methods. Secondly, in the VR environment, the user interface needs to be more concise and clear to avoid too many visual elements disturbing the user's attention. Use artificial intelligence technology to achieve intelligent prompts and assistance. By analyzing the user's behavior and habits, the system can predict the user's next action and give corresponding tips and suggestions to help the user complete the task faster.

4.3. Security and Privacy Protection Challenges

As the impact of intelligent machines on society continues to deepen, the question of whether intelligent machines in the future can control people has triggered thinking [6]. While users enjoy an immersive experience, they also face security risks such as data leakage and identity theft. VR devices usually need to collect users' biometric information, such as gestures, eye movements, etc., to provide a more personalized interactive experience. Once this biometric information is maliciously obtained, it may be used for identity authentication, fraud and other illegal activities. In order to deal with these security and privacy protection issues, strict user data usage policies should be established to clarify the regulations on data collection, use, sharing and deletion to prevent data misuse.

5. Development Trends of Human Computer Interaction Technology in Virtual Reality Scenarios

5.1. Technological Innovation

With the rapid development of science and technology, brain computer interface technology is expected to become an important breakthrough in human computer interaction in the future. By directly reading and decoding brain signals, brain computer interface technology can achieve more direct and natural human computer interaction. In recent years, human computer interaction technology in augmented reality has

been exploring more intelligent, natural and efficient interaction methods, and has become a hot topic of research at home and abroad [7]. The development of affective computing technology has also brought great changes to human-computer interaction. Affective computing technology can identify and understand human emotional states, enabling computers to respond to human needs and emotions more intelligently.

5.2. Artificial Intelligence

In the research and development of artificial intelligence products, the research hotspots of human computer interaction are mainly focused on the research of new interaction methods and interactive devices, and the research and development and application of new technologies [8]. Through the application of deep learning and machine learning, AI can analyze and understand users' interaction behaviors, thereby providing users with personalized experiences. For example, the system can learn users' preferences and habits and automatically adjust elements in VR scenes to meet users' personalized needs. By analyzing users' interaction history and behavior patterns, AI systems can predict users' possible next actions and make corresponding preparations in advance. This predictive interaction can greatly reduce user waiting time and improve the smoothness and efficiency of interaction.

Fig 4. Artificial intelligence (https://www. apa.org/ topics/ artificial-intelligence-machine-learning)

5.3. Cross Field Integration

In virtual reality scenarios, the integration trend of human computer interaction technology and technologies in other fields such as the Internet of Things and 5G communications is becoming increasingly significant. IoT technology enables real time collection, transmission and analysis of data by connecting various smart devices to the Internet. In VR scenarios, IoT technology can help achieve deep integration of virtuality and reality [9]. For example, by collecting real world data through IoT devices and mapping it into the VR environment, users can feel changes in the real world in the virtual world. The high speed, low latency and large number of connections of 5G communication technology provide strong support for human computer interaction in VR scenes. 5G technology can ensure the real time transmission of large amounts of data in VR scenes, ensuring smooth and real time user experience. The low latency feature allows users to quickly respond to operations in VR scenes, reducing the discomfort caused by delays. More user devices are connected to the VR scene at the same time, providing users with a richer and more diverse interactive experience.

6. Conclusion

By analyzing the current status and development trend of human computer interaction technology in VR scenes, the development of human computer interaction technology in VR scenes is evolving towards a more intelligent, natural and personalized direction. The application of artificial intelligence (AI) technology, especially deep learning and machine learning, enables the system to understand user intentions more accurately and provide personalized interactive experience. Although technology continues to develop, it is accompanied by some challenges. The integration of IoT technology brings more realism and immersion to VR scenes. By mapping real world data into a virtual environment, users can feel the changes in the real world in the VR world, enhancing the richness and diversity of interaction. The introduction of 5G communication technology provides strong network support for human-computer interaction in VR scenes. The characteristics of high speed, low latency and multiple connections ensure the real time and smoothness of data transmission, bringing users a better interactive experience.

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