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The Application and Development Prospects of 3D Virtual Reality Technology in Medical Simulation

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ABSTRACT
With the development of technology, 3D virtual reality technology is gradually maturing; Its application in medical simulation is becoming increasingly widespread, including anatomy teaching, surgical simulation training, rehabilitation therapy, remote medical care, etc. In the future, this technology can demonstrate better development prospects in the field of medical simulation, such as achieving high-precision modeling and real-time rendering, multimodal information fusion and interaction, personalization and intelligence, standardization and normalization, etc. This can further promote medical simulation to reach a higher level.

KEYWORDS
3D virtual reality technology; medical simulation; application; development prospects

1 Introduction

3D virtual reality technology is a hybrid technology that combines the advantages of 3D technology and virtual reality technology, creating a more immersive, interactive, and imaginative environment; Applying it to the field of medical simulation can provide a risk-free, repeatable, and efficient skill training platform for medical students, healthcare workers, and others, as well as help develop new treatment methods. In recent years, this technology has shone in the field of medical simulation, relying on better performance hardware devices and more advanced software algorithms. 3D virtual reality technology has shown tremendous potential for development.

2 The Application of 3D Virtual Reality Technology in Medical Simulation

2.1 Anatomy Teaching

Human anatomy aims to study the internal structure of the human body, providing support for more accurate diagnosis and treatment of diseases. When conducting anatomy teaching, the first step is to obtain human specimens, but it is not easy to obtain high-quality human specimens. This limits practical opportunities and affects students' learning outcomes. By utilizing 3D virtual reality technology, a "digital" human body can be constructed, manifested as the internal structure of the human body presented in digital form. This allows students to visually observe how blood flows, how bones are connected, and the arrangement of organ positions, making it easier for them to understand and master knowledge of human body structure. The "digital" human body can not only be observed from the side, but also become an object of "operation", and the process of "operation" is extremely simulated. This allows students to experience the real process of human anatomy, which can be repeated until they master the relevant knowledge and skills. This is conducive to reducing the psychological pressure of students' fear of making mistakes, and enabling them to learn and practice with a better mindset. [1] In addition, the virtual anatomy room constructed using 3D virtual reality technology can break time and location limitations, allowing students to enter it anytime and anywhere. This can greatly enhance the flexibility of anatomy teaching, create conditions for improving teaching efficiency and cultivating students' self-learning ability.

2.2 Surgical Simulation Training

Surgical training is an important part of clinical medicine. In traditional surgical training, in addition to using corpses as training vehicles, live animals are also used as experimental subjects; With the support of 3D virtual reality technology, this traditional approach can be completely changed. Firstly, relying on this technology to customize a "virtual patient", trainees can use it as a carrier for surgery. In specific customization, it is only necessary to input relevant data of real patients into the simulation system to construct a virtual patient model, such as directly customizing three-dimensional models of specific organs and tissues of patients. Secondly, this technology can be used to simulate realistic surgical scenes. The surgical scene simulated using 3D virtual reality technology is comprehensive, allowing trainees to feel as if they are in a real scene. This helps to exercise their stress resistance and thinking ability, and by designing "unexpected

situations", it can also improve their ability to adapt to situations on the spot. These abilities and accumulated experience are crucial for them to truly excel in surgical work in the future. Finally, real-time force feedback should be simulated using this technology. With the support of 3D virtual reality technology, patient tissue resistance and surgical instrument friction can be simulated during surgical training, making the surgical process more realistic. This is beneficial for improving the sensitivity of the trainees' hands, making their hand operations more precise.

2.3 Rehabilitation Therapy

The purpose of rehabilitation therapy is to help patients restore normal functions, such as cognitive function, language function, motor function, etc. The common rehabilitation treatment methods currently include physical therapy, exercise therapy, speech rehabilitation training, occupational therapy, psychological therapy, etc; And these methods, combined with 3D virtual reality technology, can greatly improve treatment outcomes. [2] For example, when using "exercise therapy" for spinal cord injury patients, 3D virtual reality technology can be used to simulate sports scenes such as cycling and swimming, and then patients can wear VR helmets to experience them. Compared with real exercise, this rehabilitation method can reduce the risk of injury for patients; At the same time, this rehabilitation method is more suitable for patients with more severe spinal cord injuries. Doctors only need to adjust the intensity of exercise in the virtual world to make these patients "move" as soon as possible; When adopting "psychological therapy" for autism patients, this technology can be used to create real-life scenarios and design specific situational intervention paradigms, allowing patients to train attention, emotion recognition, communication and dialogue skills in an immersive manner. This can not only enhance their social skills, but also stimulate their "psychology" with "context", prompting them to gradually accept life and social scenes from within; When implementing "homework therapy" for stroke patients, this technology can be used to simulate more "homework" scenarios, such as supermarket shopping, kitchen cooking, etc. After completing tasks such as shopping and cooking in these scenarios, patients can significantly improve their hand and foot mobility and further enhance their confidence; When administering medication to burn patients, this technology can be used to create a virtual environment that brings a sense of pleasure, with the aim of distracting the patient's attention and reducing pain and discomfort during medication. This can also reduce patients' anxiety and make them more cooperative in rehabilitation treatment.

2.4 Remote Healthcare

Modern communication technology is an important support for telemedicine. At present, telemedicine has achieved real-time voice and high-definition image communication, but it is still susceptible to the impact of information accuracy and completeness. 3D virtual reality technology can change this situation, helping remote medical care to be no different from "face-to-face" medical care. This can break geographical limitations and allow patients in remote areas to enjoy high-quality medical services without leaving their homes. The first is remote diagnosis. This technology can be used to build a virtual diagnosis room, where doctors and patients can meet in person by wearing VR devices; At this time, doctors can observe the symptoms and signs of patients up close. For example, when diagnosing skin problems, doctors can clearly examine the patient's skin lesions even though they are thousands of miles away, and then make accurate diagnoses. The second is remote surgery. Using this technology to construct a 'virtual patient' and a 'virtual operating room' with the same scene as the real patient, doctors can then control remote robots to complete the surgery in the virtual environment. At present, remote surgery is theoretically feasible, but there is still a long way to go before it can be fully promoted. Finally, there is remote guidance. Many patients choose to undergo home rehabilitation treatment after entering the rehabilitation stage. However, due to the lack of professional treatment knowledge among patients and their families, they need guidance from doctors, but the effectiveness of guidance through sending text and recording videos is not ideal. By using 3D virtual reality technology to create a virtual rehabilitation room, doctors can visually demonstrate rehabilitation methods here, allowing patients and their families to better grasp them. Remote healthcare can greatly improve the efficiency of medical resource utilization and effectively reduce the medical burden on patients. This also helps alleviate hospital pressure, avoid overcrowding, and provide higher quality medical services for patients.

3 The Development Prospects of 3D Virtual Reality Technology in Medical Simulation

3.1 High Precision Modeling and Real-Time Rendering

The field of medical simulation pursues further "truth". For 3D virtual reality technology, high-precision modeling and real-time rendering are important supports for achieving "reality". Therefore, this technology is constantly advancing towards these two directions in medical simulation. Modeling is the foundation for simulating "virtual patients", "virtual operating rooms", and so on. After achieving high-precision modeling, the simulated content is closer to reality. For

example, accurately simulating the subtle structures such as blood vessels and nerves of a "virtual patient" allows doctors to diagnose and treat more accurately. Real time rendering is the key to enhancing the immersion and realism of virtual environments; Its close integration with modeling technology can help virtual models achieve higher realism. After achieving higher precision modeling and real-time rendering, 3D virtual reality technology will effectively enhance the authenticity and effectiveness of medical simulation. For example, in surgical procedures, simulated anatomical structures can help doctors accurately identify and provide support for developing more refined surgical plans; Before the surgery officially begins, doctors can also conduct realistic surgical drills to ensure a smoother and more efficient surgical process.

3.2 Multimodal Information Fusion and Interaction

Medical simulation pursues stronger dynamism, manifested in the fact that simulation products can bring people a dynamic feeling. In a dynamic perspective, the types of information are more diverse; In addition to intuitive and static information such as size and length, visual, auditory, tactile, and olfactory information will also receive attention. 3D virtual reality technology has advantages in processing and integrating this information. Applying it to the field of medical simulation can not only shape more realistic products or services, but also highlight its naturalness, manifested as people feeling no different from usual when they come into contact with it. For example, in surgical drills, the virtual surgical instruments used by doctors are consistent in size, weight, temperature sensitivity, sharpness, and other aspects with those used in normal times. With the support of technologies such as gesture recognition, speech recognition, and eye tracking, human-computer interaction has become closer. For example, doctors can operate virtual models through interactive means during surgical drills, making the drill process more convenient and significantly improving the efficiency of the drill. [3] In addition to surgical drills, rehabilitation therapy can also generate higher quality treatment methods through multimodal information fusion and interactive assistance. For example, exercise therapy can provide patients with richer and more direct sensory stimulation. At the same time, patients can easily interact with the virtual environment to ensure that the treatment intensity and methods meet their own requirements, thereby achieving better rehabilitation training results.

3.3 Personalization and Intelligence

With the development and replacement of technologies such as big data and artificial intelligence, the application of 3D virtual reality technology in medical simulation will further deepen, moving towards greater personalization and intelligence. Relying on big data technology can comprehensively and deeply collect and mine patient related data; Applying these data to the construction of 3D virtual models can generate personalized treatment models that accurately match the patient's condition, thereby helping doctors develop the best treatment plan and ensuring the success rate of treatment through precise exercises in the virtual environment. With the help of artificial intelligence technology, 3D virtual reality systems will have stronger intelligence capabilities, such as the ability to automatically analyze patient data, generate personalized treatment plans, and "automatically" complete real-time feedback and guidance. In addition, artificial intelligence technology can enhance the "natural response" of "virtual patients" and further improve the authenticity of surgical drills.

3.4 Standardization and Normalization

In order to promote the sustained and in-depth application of 3D virtual reality technology in medical simulation, it is necessary to follow the path of standardization and normalization. In terms of standardization, unified technical standards can be developed to provide guidance on the specific use of the technology, ensuring that simulation products and services are sufficiently safe, reliable, and effective; In terms of standardization, strict ethical and legal norms can be established to avoid violating ethical requirements and legal regulations. For example, when using 3D virtual reality technology, data privacy protection measures should be taken to avoid adverse effects on patient information leakage. [4] Standardization and the development of norms are not something that can be achieved overnight. Continuous research and practice are needed to obtain reasonable standards and norms; At the same time, such standards and norms cannot remain unchanged, but must be continuously adjusted and innovated with the development of the times.

4 Conclusion

3D virtual reality technology has shown great potential in the field of medical simulation, but there are also many challenges, such as high equipment costs, software algorithm optimization, and ethical and legal issues. Therefore, further research on this technology is needed to promote its in-depth application in the field of medical simulation through

technological innovation, and make greater contributions to medical education and clinical practice.

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