

Exploration of Medical Product Design Development in the Field of Virtual Reality Technology

Jiamin Xiao

Changsha Social Work College, Changsha, Hunan, China

Abstract: In the era of intelligence, virtual reality technology has permeated various fields. This paper explores how to apply virtual reality technology in the field of medical product design to promote its innovation and transformation. Virtual reality technology influences product design in the medical sector, enabling the creation of a virtual three-dimensional environment. In this virtual 3D setting, product design must particularly emphasize safety and humanization. Through medical product design, patients, doctors, and medical students can simulate and experience scenarios risk-free, effectively reducing the occurrence of medical accidents. This paper studies medical product design through the lens of virtual reality technology, considering the characteristics of product design for three groups: patients, doctors, and medical students. By integrating virtual reality technology, it aims to reduce costs and risks in existing medical product designs. Under virtual reality technology, medical product design can fully consider user experience and cost control, further enhancing medical products in the virtual reality domain.

Keywords: Medical Product Design; Virtual Reality Technology; Human-Computer Interaction; Virtual Reality Education

1. Research Background

With the acceleration of population aging, medical services and efficiency, as well as outdated medical facilities, cannot meet people's needs. The quality and efficiency of existing medical services need improvement, making virtual reality technology a significant research area in medical product design. Chronic disease diagnosis and treatment, telemedicine, and personalized medicine will be new challenges in the medical field. The immersive experience and interactive nature of virtual reality technology

can effectively address these issues in medical product design[1]. Using virtual reality technology for medical product design can create products suitable for medical personnel and simulate medical environments, which can reduce medical costs, increase training opportunities for medical students and healthcare workers, and provide patients with intuitive and comfortable diagnostic experiences.

Virtual reality technology is currently used in surgical simulation, rehabilitation training, psychological therapy and so on, but its effectiveness has not met expectations due to issues like uneven resource distribution and high usage costs. However, virtual reality technology remains a primary driver of innovation in the medical field. In recent years, the medical sector has been a key focus of support globally. With the impetus of virtual reality technology, medical product design has received substantial financial and technical support, facilitating the transition from laboratory to market. Maturity, low cost, and user experience have become critical benchmarks for evaluating virtual reality medical products.

The widespread adoption and promotion of virtual reality technology in medical product design have not yet occurred. High equipment costs, excessive energy consumption, poor user adaptability, and difficulties in privacy protection are current challenges. The application of virtual reality technology in medical product design still faces obstacles such as technological compatibility, standardization, and a shortage of specialized talent. These problems require mutual promotion between virtual reality technology and medical product design to explore healthy development in the medical field.

2. Current Research Trends and Challenges

The degree of research in the field of medical product design is closely related to the development of virtual reality technology, especially in improving user experience through

virtual reality technology. As virtual reality technology continues to evolve, the scope of medical product design applications in training, telemedicine, rehabilitation therapy, and other scenarios is expanding. Virtual reality technology has become a key force driving innovation in medical product design within the healthcare industry[2].

Virtual reality application technology is a double-edged sword in medical product design, affecting factors such as device portability, user interface friendliness, and system response speed. In medical product design, the primary challenge is the cost of popularizing virtual reality application technology, as well as hardware and software development costs, which are major barriers to product promotion. Most existing virtual reality technologies are unstable, with difficult-to-meet equipment requirements. These technical failures could lead to serious medical accidents, so safety and stability are crucial issues in the application of virtual reality technology in medical product design.

3. Overview of Virtual Reality Technology

3.1 Current Status of Virtual Reality Technology Application in Medical Product Design

Virtual reality technology is rapidly developing in the field of medical product design. In recent years, with the continuous advancement of virtual reality application technology, its use in medical product design has extended from educational domains to medical practice. The Guangzhou Orthopedic Hospital has adopted VR+3D technology to provide innovative solutions in medical education and training, telemedicine, rehabilitation therapy, and psychological treatment. These measures have not only improved the quality of medical services but also significantly expanded the boundaries of medical practice.

As virtual reality technology is further researched, traditional two-dimensional medicine is being replaced by three-dimensional visualization medical environments based on virtual reality technology, including 3D reconstruction, 3D printing, and virtual simulation. The high immersion and interactivity of virtual reality technology provide medical personnel with an ideal virtual platform to develop different solutions that cater to patients' individual needs[3]. Virtual reality technology also has a

certain impact on mental health treatment, offering patients a novel therapeutic experience. By constructing realistic virtual scenarios, patients can face and overcome psychological barriers in a safe and controlled environment, which is significant for treating anxiety disorders, phobias, and other mental illnesses.

4. Application of Virtual Reality Technology in Medical Product Design

4.1 Integration of Human-Centric Thinking and Technology

Incorporating virtual reality technology into medical product design embodies the perfect fusion of human-centric design thinking and technological innovation. This integration not only enhances the humanization of medical product design but also transforms educational and medical training methods to some extent. Through virtual reality technology, medical product design becomes more diverse and humanized, allowing students and medical professionals to simulate medical procedures in a virtual environment, thereby reducing accidents, increasing efficiency and safety, and lowering training costs to a certain extent[4]. Currently, the application of virtual reality technology in medical product design is primarily system-based, such as obstetric virtual simulation training systems and emergency nursing virtual simulation training systems, which enhance students' practical abilities and bring about new educational reforms in medical education.

The integration of medical product design and virtual reality technology requires a greater focus on user sensory experience and operational intuitiveness. During medical product design, virtual reality technology can be used to simulate real-life usage scenarios, enabling design teams to better and more accurately design medical products. This ensures that medical products not only fulfill their functions but also align with the human-centric philosophy, making them ergonomic and meeting the operational needs of medical and teaching staff. For instance, in virtual medical teaching surgeries, teachers and students can repeatedly practice using medical products and virtual reality technology, achieving proficiency and thus reducing errors and increasing success rates[5].

Under the influence of virtual reality technology, medical product design and development ensure that products are more suitable for actual

operating environments and personnel operations. This highlights the important role of virtual reality technology in medical product design and development, particularly in the later stages of product development and operation feedback. In a virtual environment, designers can quickly adjust medical products, anticipate and understand product shortcomings, shorten development cycles, and reduce unnecessary waste. This approach accelerates the flow of medical products into the actual market, speeding up the update and iteration process in education, medical, and other fields.

4.2 Sensory Experience Optimization at the Product Design Stage

Virtual reality technology enhances users' sensory experiences during the medical product design phase. Designers create immersive interactive environments through virtual reality technology, immersing users in the actual effects of medical product design. Through three-dimensional interactive visual, auditory, and tactile feedback, medical products are comprehensively displayed in a virtual environment. Users can accurately convey information during the experience, promoting design updates and iterations[6]. For example, when designing surgical instruments for medical products, designers use virtual reality headsets or VR glasses and hand tracking devices to establish a three-dimensional virtual reality operating room. Doctors can rehearse surgeries in advance in the virtual operating room, optimizing the product design experience and ensuring comfort and precision during the surgery.

When designing medical rehabilitation products, personalized adjustments are crucial for enhancing patient adaptation and improving rehabilitation efficiency. Emotional experiences in a virtual reality environment are an aspect that medical product design should pay attention to. By sensing emotional changes during product use and instantly adjusting the virtual scene, a more positive therapeutic atmosphere is created, promoting patients' psychological recovery[7].

5. Advantages and Limitations of Virtual Reality Technology in Medical Product Design

5.1 Enhancement of User Sensory Experiences

Through the empowerment of virtual reality technology, medical product design significantly improves user experiences, especially in terms of

visual, auditory, and tactile senses. Through immersive virtual reality environments, users can experience more intuitive and vivid interactions, providing significant advantages in the experience of rehabilitation, surgical, and diagnostic products[8].

Virtual reality technology enables medical products to offer precise sensory experiences. For rehabilitation product designs, targeted exercises can be conducted in a virtual environment based on specific movements. These exercises can identify changes in the user's psychological and emotional states, instantly altering the virtual reality environment to achieve better training outcomes. This aligns with customized experiences, increasing user engagement and satisfaction, making the rehabilitation process more humane.

Enhancing the sensory experience of virtual reality in medical product design presents certain challenges. Designers need to address discomfort caused by prolonged use and achieve seamless connections between virtual environments and the real world. Collecting feedback from multiple senses such as vision, touch, and hearing allows designers to create all-encompassing immersive experiences[9]. This direction enhances the appeal and practicality of virtual reality medical products, meeting patients' diverse needs in areas such as movement, speech, emotion, and social interaction.

5.2 Enhancement of Precision and Real-Time Performance

Regarding the effectiveness of medical product use, virtual reality technology significantly improves the precision and real-time performance of treatment processes in medical product design. Doctors can simulate surgical plans through high-precision virtual reality three-dimensional scenes when using medical products, precisely planning each operation to minimize risks during surgery. This practice not only increases surgical safety but also allows doctors to practice repeatedly in a safe environment, increasing the likelihood of successful surgeries. For instance, in tumor resection surgeries, virtual reality technology can provide detailed images of tumors and surrounding tissues, enabling doctors to more accurately identify and separate tumor boundaries, reducing damage to healthy tissue.

In the field of rehabilitation product design and treatment, virtual reality technology can create

three-dimensional immersive rehabilitation scenarios. Patients undergo physical therapy or cognitive training in virtual settings, where the system can update motion data in real time and adjust according to the patient's responses, ensuring that the rehabilitation plan is both challenging and safely controllable. Through virtual reality technology, medical product design transcends traditional boundaries, opening new paths for precision medicine and personalized treatments.

5.3 Limitations and Challenges of Existing Technologies

The limitations and challenges of applying virtual reality technology in medical product design are particularly prominent. Medical product design requires close collaboration with experts from clinical, IT, and other fields to ensure that the integration of medical products and virtual reality technology meets the needs of the medical industry[10]. In the field of virtual reality technology, the accuracy of digital modeling, the validity and similarity of models, image quality, and real-time performance are critical aspects that are easily constrained by existing technologies.

Although virtual reality technology demonstrates great potential in medical product design, its existing limitations cannot be overlooked. From aesthetic and technical perspectives, relying solely on designers' personal aesthetics and experience is no longer sufficient to meet the complex demands of medical product design[11]. With advancements in digital technology and the rise of the experience economy, medical product design requires a more systematic approach to address growing challenges and expectations. Future research should focus on overcoming these technological limitations while exploring how to more effectively integrate product system design theories into medical product design to achieve more accurate and safer medical solutions.

6. Future Prospects of Virtual Reality Technology in Medical Product Design

6.1 Technological Development Trends

As technology advances, virtual reality technology in future medical products will place greater emphasis on user experience and personalized needs[6]. Virtual three-dimensional visualization scenes and human-computer

interaction experiences provide doctors with more intuitive medical imaging during surgical planning, enabling them to achieve more precise execution of surgeries. Virtual reality technology can simulate complex medical scenarios in education, offering medical students a safe, risk-free platform for practical training, greatly enriching teaching content and formats. The application of virtual reality technology in medical product design heralds the arrival of a new era centered around patients, emphasizing personalization and intelligence.

The integration of virtual reality technology with cutting-edge technologies such as artificial intelligence and big data represents a development trend that allows medical product design to continuously innovate under the empowerment of virtual reality technology. For example, in the field of telemedicine, virtual reality technology can construct virtual consultation rooms, breaking geographical barriers and enabling remote communication between patients and doctors. In the area of rehabilitation treatment products, virtual reality technology enables customized rehabilitation, providing patients with more comfortable and enjoyable treatment experiences. The application prospects of virtual reality technology in the field of medical product design are extensive, promising profound impacts on the healthcare industry.

6.2 Expansion of Application Areas

The application of virtual reality technology in medical product design is gradually expanding to broader areas, from initial surgical products to current telemedicine, psychotherapy, rehabilitation assistance products, and education and training systems. Virtual reality technology is becoming increasingly mature in the field of medical product design. Particularly in the realm of cost reduction, the application of mixed reality (MR) glasses has significantly enhanced the precision of product use, providing more intuitive and precise three-dimensional scenes for complex surgeries, reducing surgical risks, and increasing success rates.

As virtual reality technology continues to advance, its value in medical education and training is increasingly evident. Surgical simulations in virtual environments not only compensate for the lack of clinical practice opportunities but also drastically reduce practical risks, cultivating more medical talents with

hands-on experience. With the integration of cutting-edge technologies such as artificial intelligence and big data, virtual reality technology is expected to play a greater role in medical product design in areas such as image analysis and surgical simulation training, accelerating the industry's transition towards intelligence and personalization.

7. Conclusion

The application of virtual reality technology in the field of medical product design brings new technologies and directions to the transformation of the medical industry. The utilization of virtual reality technology significantly enhances the precision and efficiency of medical product design, particularly in surgical planning, rehabilitation training, and patient education, demonstrating significant advantages. It assists doctors in formulating more refined surgical plans for patients, thereby increasing the success rate of surgeries. Interdisciplinary cooperation becomes a core driving force for innovation in medical product design with virtual reality technology. The integration of design

discipline expertise and virtual reality technology in medical product design not only strengthens product functionality but also improves user experience. Through the exchange and integration of disciplines such as medicine, design, and virtual reality technology, it ensures that medical products meet technical needs while also considering humanistic care.

Virtual reality technology still faces numerous constraints in its widespread application in the current medical product field. Factors such as technology costs, device portability, and user training are hindrances to its development. The promotion of intelligent and personalized development in the medical product field by virtual reality technology requires further enhancement. In summary, the application prospects of virtual reality technology in the field of medical product design are broad, which cannot be achieved without the joint efforts of the medical, design, and industrial sectors to overcome existing technological and market challenges.

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