Research and Application of Virtual Reality Technology Based on the Medical Field of Autism

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Abstract. With the rapid advancement of technology, virtual reality has revolutionized various industries, including healthcare. In particular, the treatment of autism has greatly benefited from the integration of virtual reality technology. This study aims to provide an analysis and summary of the recent advancements and applications of virtual reality in the medical field for autism, based on a comprehensive literature review. It investigates how virtual reality technology is currently helping individuals with autism to alleviate the difficulties caused by complex symptoms, and explores effective treatment and rehabilitation approaches for different types of autism spectrum disorder. The study also examines specific autism disorders, such as social interaction difficulties and emotional regulation challenges. Furthermore, it outlines the numerous challenges that virtual reality technology faces in its development for medical applications in the field of autism. Finally, the paper concludes and offers future prospects in this domain.

Keywords: Virtual reality technology; medical field of autism; research methods; application status.

1. Introduction

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental disorder characterized by difficulties in social interaction, cognitive deficits, difficulties in self-care, and repetitive and fixed patterns of behavior, often accompanied by other psychological disorders such as anxiety and depression[1]. In recent years, the diagnosis rate of ASD has significantly increased, causing profound distress to patients and their families. Therefore, finding more effective and targeted treatment methods to help patients recover has become a pressing issue. The maturing development of Virtual Reality (VR) technology has created new possibilities for the treatment of autism. VR integrates advanced technologies such as modern computer graphics, simulation, and human-computer interaction, providing an immersive experience through the construction of a three-dimensional environment [2]. Since its inception, this technology has been continuously innovated and widely applied in various fields such as medicine, aviation, science, and biology, especially in the medical field, greatly promoting its development [3].

In the current medical field of autism, VR has carved out its unique treatment method. By targeting this field and its subcategories, VR can dissect the differences between various categories, thereby accurately constructing virtual three-dimensional environments for effective treatment and rehabilitation training of different ASD patients. This not only reduces their fear and stress of real social scenarios but also helps them better cope with and adapt to various situations. The methods of rehabilitation training are also becoming more diverse, such as clinical skills training, visual function training, surgical treatment, psychotherapy, and telemedicine, etc[4].

However, although the application of VR in the research of the medical field of autism has achieved some preliminary results, it still faces many problems and challenges. For example, how to integrate this technology more effectively into the treatment process to allow more ASD patients to learn and adapt easily, and how to solve the high time, space, and economic costs of current research and application. These issues require further research and discussion.

This paper aims to explore the research and current applications of VR in the medical field of autism. It will analyze how VR offers precise and efficient treatment and rehabilitation training for complex cases of ASD, based on recent literature and studies. Additionally, the paper will highlight

the difficulties and challenges encountered in this area. Finally, it will provide insights and perspectives on the future of VR research and application in the field of autism.

2. Application of Virtual Reality Technology in Autism

VR offers a multi-dimensional, novel perspective and means, creating more possibilities for the treatment of autism, enabling medical researchers to intervene and train more effectively. Specifically, the research and application of Virtual Reality Technology in the field of autism medicine mainly cover four important aspects: social skills training, emotional regulation training, cognitive enhancement training, and sensory hypersensitivity therapy. In this section, this paper will delve into each of these four aspects of research and application, in order to better understand how Virtual Reality Technology is shaping and changing the current status and future of treatment in the field of autism medicine.

2.1. Social Skills Training

Individuals with Autism Spectrum Disorder often experience anxiety and unease when faced with social interactions, frequently due to uncertainty or lack of knowledge on how to respond.

A unique advantage of virtual reality technology, as widely recognized, is its ability to provide a variety of attractive and adjustable learning environments [5]. Researchers can employ virtual reality technology to simulate and recreate various real-life social scenarios to assist individuals with autism in overcoming social interaction difficulties.

Fig.1 Environment for Social Skills Training in Individuals with Autism.

For instance, we can simulate scenarios in parks, shopping malls, or schools, allowing patients to interact with virtual people or objects. These interactions can range from simple greetings and conversations to more complex social activities, such as teamwork. As depicted in Fig. 1, an individual with autism is engaging in a simple shopping activity in a simulated mall environment through virtual reality technology, training their social communication skills and their ability to handle situations in the outside world. In these simulated social interactions, patients can learn and practice eye contact, understanding and using non-verbal signals, and expressing their thoughts and feelings clearly in a safe, stress-free environment.

However, this represents an ideal implementation state. In practice, there are still some limitations. For example, the technology has not yet reached a point where every patient is willing to understand and agree to the training. Additionally, the construction of internal simulation scenarios is not yet mature, and there remains some discrepancy with reality.

2.2. Cognitive Enhancement Training

Virtual reality technology can also be employed to enhance the cognitive abilities of patients with autism. For instance, when dealing with autistic patients who have cognitive impairments, research medical teams design a simulated virtual game environment for training and treating these patients. As depicted in Fig. 2, children with autism are seen comfortably and joyfully engaging in a game scenario simulated by virtual reality. Gradually, they become more willing to accept information from the outside world and learn corresponding skills and knowledge. This project successfully integrates cognition, physical activity, and entertainment, enabling patients to repeatedly apply their cognition and strengthen their physical activity capabilities in a virtual yet enjoyable setting [6].

Fig. 2 Cognitive Enhancement Training for Autism Patients through Simulated Game Environments Using Virtual Reality Technology

In addition, VR can serve as a significant tool for data assessment. After constructing a virtual scenario for controlled variable experiments on patients, complex data reports can be analyzed and examined through VR. The statistical results can accurately and swiftly determine the effectiveness of the experiment in the medical field of autism, continuously refining to derive the optimal treatment plan for cognitive impairments [7]. Through this method of experiencing game scenarios, patients with autism can effectively enhance their memory, attention, and problem-solving abilities in fun and novel games. Simultaneously, real-time game scenario data recording and analysis can gradually provide individualized plans for each patient, thereby advancing detailed treatment and rehabilitation.

2.3. Emotional regulation training

Patients with autism often face numerous difficulties in emotional regulation. They may have excessive reactions and feelings towards negative emotions such as frustration, loss, or stress, or they may be unable to understand and handle these emotions. However, researchers can create various challenging and stressful situations, such as complex work tasks, social conflicts, or adaptation to new environments, by utilizing VR.

For instance, one study attempted to compensate for the therapeutic effects of the natural environment by creating a virtual environment, thereby providing more comprehensive and detailed conditions for the rehabilitation of patients with autism. The results of the test successfully demonstrated the feasibility of this research [8]. Under the same theme, another study explored whether VR could establish a detailed and independent interaction database based on the emotional feedback of different patients with autism, given the significant differences in individual responses to environmental stimuli. The results of this study also successfully met expectations, achieving the maximization of emotional healing benefits for each patient with autism [9].

Through this training, the group of patients with autism participating in the experiment successfully learned how to correctly handle different negative emotions, strive to remain calm, and effectively express and manage their emotions. Of course, this is just the positive outcome of the

research. The application of this method to all patients is still in the development stage and is in its infancy.

2.4. Sensory hypersensitivity therapy

Patients with autism may have strong reactions to sensory stimuli that seem ordinary. These stimuli can be auditory (such as car horns or voices), tactile (such as the texture of clothing or temperature changes), or visual (such as intense light or complex colors). Hypersensitivity to these stimuli may cause discomfort or anxiety in certain environments (such as noisy streets, crowded malls, or colorful places). Specifically, sensory desensitization therapy is achieved by using VR to simulate various environments and situations, allowing patients to gradually adapt to different sensory stimuli under safe and comfortable conditions [10].

For instance, for patients sensitive to noise, VR can gradually increase the noise level in the virtual environment, allowing patients to gradually adapt to higher noise levels without actual noise. For patients sensitive to light, VR can adjust the intensity and color of light in the virtual environment, helping patients gradually adapt to different light conditions.

Compared to this, although other therapies, such as social skills training or emotional regulation training, can also be achieved through VR, they generally require longer time and more practice to see effects. Moreover, these therapies often focus on improving patients' behaviors and ways of thinking, rather than directly addressing their sensory hypersensitivity symptoms.

In addition, the effects of sensory desensitization therapy are relatively easy to measure and observe. For example, patients can directly report their comfort level with specific stimuli, or their physiological responses (such as heart rate or skin conductance) can be used to measure their reactions to stimuli. Therefore, although the application of VR in autism therapy is not limited to sensory desensitization therapy, the directness and measurability of this therapy make it an important application of VR in this field.

2.5. Facing Challenges

Although VR has achieved some success and promotion in the field of autism medicine today, it still encounters many unavoidable difficulties and challenges at this stage.

Challenge 1: The high cost and technical difficulties of VR

When applying VR to the research of the medical field of autism, the economic input cost is very high, and the equipment cost and accessibility must also be considered. Although the price of VR equipment is gradually decreasing, the high price is still a significant barrier for many users and medical institutions [11]. In addition, VR devices require users to have certain technical knowledge to use, which may pose challenges to some users (especially older or less technologically knowledgeable users).

Challenge 2: Individual differences in autism patients and the challenge of personalizing VR therapy

In addition to this, individual differences are currently a significant obstacle preventing the further advancement of research applications of VR based on the medical field of autism. As is well known, the symptoms and reactions of each autism patient are unique. Therefore, the same VR therapy may not produce the same effect on all patients. This requires the personalization of VR therapy, but this not only increases the complexity of the treatment but also once again increases the cost.

2.6. Future Prospects

Looking towards the future, even though the application of VR in the field of autism medicine has encountered some difficulties and challenges, this cannot hinder the progressive development of virtual reality. Starting from the current stage and looking forward to the journey ahead, with the continuous innovation and development of VR technology, this paper outlines the following three development plans for VR based on the field of autism medicine:

Personalized Treatment Plans

VR needs to be able to customize for the specific needs of each individual with autism, providing a variety of different social scenarios, sensory stimuli, and behavioral training, thereby achieving more personalized treatment.

Efficient and Cost-Effective Treatment Modes

Future VR should become an efficient and cost-effective treatment mode, providing a risk-free, controllable simulated environment that allows patients to practice and learn new skills under safe conditions.

Integration with Emerging Technologies

VR can also be combined with other emerging technologies (such as artificial intelligence, neurofeedback) to provide more comprehensive solutions for research and application in the field of autism medicine.

3. Conclusion

This paper deeply discusses the four main applications of VR in the field of autism medicine: social skills training, cognitive enhancement training, emotional regulation training, and sensory hypersensitivity therapy.

In terms of social skills training, VR technology can simulate various social scenarios, helping individuals with autism learn and practice social skills through interaction with virtual characters, such as making eye contact, understanding and using non-verbal signals, and expressing their thoughts and feelings clearly. In the realm of cognitive enhancement training, VR technology can design virtual game environments, combining cognitive training, physical activity, and entertainment to help individuals with autism improve memory, attention, and problem-solving abilities. VR technology can also serve as a data assessment tool, providing references for treatment plan selection through the analysis of experimental data. In the area of emotional regulation training, researchers can use VR technology to create various situations, helping individuals with autism learn to handle negative emotions and strive to remain calm. Simultaneously, VR technology can assist them in effectively expressing and managing their emotions. In the context of sensory hypersensitivity therapy, VR technology can provide a safe, controllable environment, simulating various sensory stimuli that may cause allergic reactions, helping individuals with autism gradually adapt to these stimuli. Although VR technology has achieved certain results in the field of autism medicine, it still faces challenges such as high economic investment, low equipment accessibility, and high individual variability. VR has infinite exploration possibilities and tremendous potential in the research of autism medicine.

However, in the process of vigorously promoting VR technology research and development, human care should not be overlooked. The feasibility of technology and group acceptance are closely related to a people-oriented approach. In the future, VR technology is expected to solve these problems through technological innovation and integration with other emerging technologies, providing more comprehensive and personalized treatment plans for the field of autism medicine.

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