Research on the Influence of Multiple Interaction Mechanisms on the Enhancement of VR Game Users' High Immersion Experience and the Effect of Virtual-Real Integration

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Abstract: This study focuses on the application of multiple interaction mechanisms in VR games, and deeply discusses its role in enhancing users' high immersion experience and its impact on the virtual-real fusion effect. Based on the analysis of the current status of VR game interaction technology, combined with the user experience theory and relevant research on immersion, this paper analyzes in detail how multiple interaction mechanisms including motion capture, haptic feedback, voice interaction and other interaction modes work together to affect users' immersion in VR games from multiple dimensions such as sensory stimulation, cognitive participation and emotional resonance. At the same time, the contribution of these interaction mechanisms to enhancing the virtual-real fusion effect is studied, including improving the matching degree of virtual environment and real action, and enhancing the real texture perception of virtual objects. The theoretical correlation model of multiple interaction mechanisms, immersion and virtual-real fusion effect is constructed to explain its internal logic and action path. Empirical research method was adopted to collect user data and conduct quantitative analysis to verify the significant correlation between multiple interaction mechanisms and users' high immersion experience and good virtual-real integration effect. Based on the research results, optimization strategies for VR game design and development were proposed, with a view to providing theoretical basis and practical guidance for promoting the development of VR game industry.

Keywords: VR Games; Multiple Interaction Mechanism; Immersion; Virtual-Real Fusion.

1. Introduction

German literary critic Walter Benjamin once said: In the dialectical process between art production and consumption, breaking the ivory tower of art and introducing the public to the temple of art appreciation is one of the points [1]. From the perspective of interaction forms, traditional game human-computer interaction mainly uses keyboard, mouse and screen as interactive devices, and the design focuses on UI interface interaction design [2]. Liu Lin [3] believes that users are the core of game interface design, and proves through a large number of practical cases that the basis of fun and interaction in games is interface graphics. Li Zhe [4] found that interface interaction and game usefulness are the core of successful online games through a large number of competitive product research analysis and user research, and developed a shooting game based on this theory and was widely praised. When studying the immersive interface of multiplayer online competitive games, Tao Yiwen [5] explored the features and interaction design methods of the interface from three aspects: interaction structure, visual style and dynamic expression.

With the vigorous development of VR industry, previous researches on VR mainly focus on four aspects: the interaction of new technologies, subjective and objective measurement methods, the impact of player perspective on game experience, and the impact of time delay on vertigo [6]. As early as 1990, virtual reality technology has been used as an assistive technology in the medical field to develop VR medical applications [7], which relieve patients' pain through games and guide patients to shift their attention from the pain state to other things. Chittaro and Buttussi developed a VR game to improve the awareness of aviation safety education, so that users can personally experience the emergency landing and evacuation of an aircraft after an accident [8]. Ma, Zhang and Li designed a virtual reality game for physical education games by combining virtual reality technology with

education through Microsoft access motion-sensing devices [9].

VR games are gradually emerging as a form of entertainment with great potential. Immersion, as the core experience feature of VR games, directly affects users' acceptance and satisfaction with games. The multi-interaction mechanism is the key factor to achieve high immersion experience and good virtual-real fusion effect. Streppel, Pantforder and Vogel-Heuser studied users' preference for gesture control (direct user interaction), physical controller control (physical control) and virtual user interface element control (virtual control), and found that users' preference for gesture control and physical control is the same [10]. Bogost said [11] that while traditional gamepads use the movement of a certain part of the player's body to control the movement of characters on the screen, new controllers require the player to use the whole body, which makes symbolic movement in games more realistic. In-depth research on the function mechanism of multiple interaction mechanisms in VR games is of great significance for improving the quality of VR games and expanding its market application.

2. Status Quo of VR Game Interaction Technology

2.1 Motion Capture Technology

Motion capture technology is one of the commonly used interactive means in VR games. It monitors and captures players' body movements in real time through sensors, and converts players' body movements into character actions in the game. At present, the main motion capture technologies include optical motion capture, inertial motion capture and motion capture based on depth camera. The optical motion capture has high precision, but the equipment is expensive and the environment requirements are high. Inertial motion capture has the characteristics of strong portability, but there is a certain drift error. Depth-camera-based motion capture costs are relatively low and can meet the needs of home users to a certain extent. For example, in some large VR game experience centers, optical motion capture technology is mostly used to provide players with high-precision interactive experience, and in consumer VR devices, motion capture technology based on depth cameras or inertial sensors is more widely used.

2.2 Haptic Feedback Technology

Haptic feedback technology aims to provide players with realistic tactile feelings and enhance the immersion of the game. Common tactile feedback techniques include vibration feedback, force feedback and electrical stimulation feedback. Vibration feedback by setting up a vibration motor in a gamepad or wearable device, vibration of different intensity and frequency is generated according to the game situation, such as in a shooting game, simulating the recoil vibration of a gun shooting. Force feedback can precisely apply force to the player based on the interaction in the game, for example, in a driving simulation game, the player can feel real resistance when turning the steering wheel. Electrical stimulation feedback technology is relatively rarely used. It stimulates skin nerves through weak electrical pulses to generate tactile perception, but it is still in the research and improvement stage because it may cause certain discomfort to the human body.

2.3 Voice Interaction Technology

Voice interaction technology is increasingly widely used in VR games, players can talk with the game character through voice commands, control the game process or get game information. The continuous development of speech recognition technology has significantly improved the accuracy of speech interaction, and can support a variety of natural language processing functions. For example, in some adventure games, the player can communicate with non-player characters (NPCS) via voice to get quest clues or trigger story development, which greatly improves the interactivity and ease of the game.

3. Theoretical Basis for the Integration of Immersion and Virtual Reality

3.1 Connotation and Dimension of Immersion

Immersion refers to a psychological state in which the user is fully engaged in a specific environment. In VR games, it is mainly reflected in three dimensions: sensory immersion, cognitive immersion and emotional immersion. Sensory immersion is the immersive feeling generated by the stimuli received by the user through the visual, auditory, tactile and other sensory channels, such as realistic 3D pictures in VR games, surround sound effects and haptic

feedback help to enhance sensory immersion. Cognitive immersion refers to the user's in-depth understanding and focus on the game rules, tasks, plots and other content during the game process. When the difficulty of the game matches the player's skill level, cognitive immersion can be promoted. Emotional immersion is when the user has an emotional resonance with the characters and plot of the game. For example, in a touching game story, the player may have an emotional experience such as sadness, joy, or tension, thus enhancing the immersion of the game.

3.2 Concept and Realization Elements of Virtual-Real Integration

Virtual-real integration is an important feature of VR games, which emphasizes the organic integration of virtual world and real-world information, making it difficult for players to distinguish between virtual and real world in the process of perception and interaction. The realization of virtual-real fusion requires high precision and coordination in spatial positioning, object recognition and interactive response. Spatial positioning technology can accurately track the player's position and posture in real space, and map it to the virtual environment to ensure that the player's actions in the virtual world match the real action. Object recognition technology enables objects in the virtual environment to recognize the player's interaction intention, such as when the player reaches out to touch the virtual object, the game can accurately judge and make corresponding feedback. The timeliness and accuracy of interactive response are also key elements of virtual-real integration, and any interactive operation of the player should get an immediate and reasonable response in the virtual environment, so as to enhance the player's perception of the effect of virtual-real integration.

4. The Impact of Multiple Interaction Mechanisms on Immersive Experience

4.1 The Effect of Motion Capture on Immersion

By capturing the player's body movements in real time, motion capture technology enables players to interact with the game world in a more natural and intuitive way. At the sensory level, the player's body movements can be directly transformed into the actions of the game character, enhancing the sense of visual synchronization and realism. For example, in VR fighting games, the player's boxing and kicking actions can be accurately presented to the game character, making the player seem to be in a real fighting scene. At the cognitive level, motion capture requires players to understand the game character's action logic and interaction rules more deeply, thus improving cognitive immersion. For example, in some puzzle-like VR games, the player needs to use specific body movements to trigger the mechanism or solve the puzzle, which makes the player more focused on thinking and performing the game task. At the emotional level, motion capture can enhance the emotional connection between the player and the game character. When the player's actions can directly affect the game character's emotional expression or plot development, it is easy to trigger emotional resonance. For example, in a role-playing game, the player's friendly actions may make the game character feel grateful, thus promoting the plot to develop in a positive direction.

4.2 Enhancement Effect of Haptic Feedback on Immersion

Haptic feedback technology significantly improves the immersion of VR games from the tactile sensory dimension. In terms of sensory immersion, different types of tactile feedback can simulate a variety of real tactile feelings, such as vibration feedback simulation of collision, friction and other feelings, force feedback simulation of the weight and texture of the object, so that players can feel more realistic tactile stimuli when touching virtual objects. For example, in VR simulation surgery games, force feedback technology can allow players to feel the real resistance between surgical instruments and human tissues, improving the realism of the game scene. In terms of emotional immersion, haptic feedback can trigger emotional responses from players. For example, sudden strong vibrations may make players nervous or frightened, while soft tactile stimuli may bring feelings of comfort or peace of mind. These emotional experiences, combined with the game plot, can enhance the depth of emotional immersion for players.

4.3 The Promoting Effect of Voice Interaction on Immersion

Voice interaction technology enriches the

interactive ways of VR games, and the improvement of immersion is mainly reflected in cognitive and emotional levels. In terms of cognitive immersion, voice commands make it easier for players to control the game process, obtain game information, reduce the complexity of operations, and enable players to focus more attention on the game content itself. For example, in large-scale open world VR games, players can quickly query maps, mission information or communicate with NPCS through voice commands, improving the efficiency and fluency of game exploration. In terms of emotional immersion, voice interaction can create a more real social atmosphere. When players have a natural and smooth voice dialogue with the characters in the game, emotional resonance is easy to occur. Especially in games with rich story and character creation, voice interaction can enable players to better understand the emotions and motivations of the characters and enhance the emotional immersion experience.

4.4 Synergistic Effects of Multiple Interactions

Multiple interaction mechanisms in VR games do not exist in isolation, but cooperate with each other to enhance the user's immersion experience. The combination of motion capture and haptic feedback enables the player to feel the corresponding tactile stimulation while operating the game character, which enhances the sense of reality and coherence of the interaction. For example, in VR sports games, the player's batting action is presented through motion capture, while matching the vibration feedback and force feedback of the moment of batting, so that the player seems to be really playing sports. The collaboration of voice interaction with motion capture and haptic feedback further enrichis the dimension of interaction. For example, in a team VR game, players can coordinate team actions through voice commands, perform actual operations combined with motion capture, and feel various interaction effects in the game through haptic feedback. This synergistic effect of multiple interactions can comprehensively enhance users' immersion experience from sensory, cognitive and emotional dimensions. Make the player more deeply into the VR game world.

5. The Influence of Multiple Interaction Mechanisms on the Effect of Virtual-Real Fusion

5.1 Improve the Matching Degree between Virtual and Real Actions

The motion capture technology in multiple interaction mechanism is the key to realize the matching of virtual and real motion. Through high-precision motion capture equipment, the player's physical movements in real space can be accurately mapped to the virtual environment, ensuring that the game character's movements are highly consistent with the actual movements of the player. For example, in the VR dance game, the player's dance movements can be presented in real time on the virtual character, whether it is the swing amplitude, speed or rhythm of the limbs, it can be accurately matched, so that the player is visually difficult to distinguish the difference between virtual and real movements, thus greatly enhancing the effect of virtual and real integration. At the same time, other interaction technologies such as haptic feedback and voice interaction can also work with motion capture to further enhance this match. For example, on the basis of motion capture, haptic feedback provides the corresponding tactile feelings according to the player's actions, and voice interaction can provide voice prompts or feedback according to the player's action state, making the entire interaction process more coordinated and improving the overall effect of virtual-real integration.

5.2 Enhance the Real Texture Perception of Virtual Objects

Haptic feedback technology plays an important role in enhancing the perception of real texture of virtual objects. Under the multiple interaction mechanism, when the player touches the virtual object, the haptic feedback can provide corresponding tactile stimuli according to the material properties of the virtual object, such as the smooth motion of the smooth surface, the friction of the rough surface, etc., so that the player can feel the texture of the virtual object more truly through haptic perception. For example, in the VR home design game, when the player touches the virtual furniture, the tactile feedback can simulate the touch of different materials such as wood, metal, fabric, etc., so that the player seems to really touch the physical furniture, thus enhancing the reality of

the virtual object in the tactile dimension, and further enhancing the effect of virtual and real integration. In addition, motion capture and voice interaction can also be combined with haptic feedback to enrich the player's perceptual experience of virtual objects. For example, players pick up virtual objects through motion capture, tactile feedback provides a sense of the weight of the object, and voice interaction can provide detailed information about the object, so that players can feel the real existence of the virtual object from multiple angles, improving the fidelity of the virtual and real fusion.

6. Construction of Theoretical Correlation Model between Multiple Interaction Mechanisms, Immersion and Virtual-Real Fusion Effect

In the process of in-depth analysis of the impact of multiple interaction mechanisms on the immersive experience of VR game users and the effect of virtual-real integration, the construction of a theoretical correlation model is helpful to systematically understand its internal logic and action path.

From the perspective of immersion dimension, multiple interaction mechanisms build a bridge closely connected with all levels of immersion through the synergistic effect of multi-sensory stimuli. As an intuitive means of interaction, motion capture technology maps players' body movements onto virtual characters in real time at the level of sensory immersion, enabling players to visually directly perceive the close connection between themselves and the virtual world. Such visual coherence and synchronization is an important cornerstone of sensory immersion. For example, in VR adventure games, the player's running and jumping actions are accurately presented on the character, strengthening the sense of reality of visual feedback. From the perspective of cognitive immersion, motion capture requires players to operate according to the action logic in the virtual environment, prompting players to think deeply about the game rules and task requirements, such as in complex VR puzzle games, specific combinations of body movements are used to solve puzzles and stimulate players' deep cognition of the game mechanism. In terms of emotional immersion, the player's actions can trigger the emotional response of the virtual character or promote the development of the emotional context of the story. For example, in role-playing VR games, the interactive actions between the characters trigger emotional resonance, so that the player is immersed in the game situation with intertwined emotions.

Haptic feedback technology mainly focuses on sensory and emotional immersion dimensions. In terms of sensory immersion, it provides players with physical perception beyond sight and hearing by simulating various tactile sensations, such as vibration and force feedback. In VR shooting games, the recoil vibration of gun shooting and the haptic feedback of hitting the target greatly enrich the player's sensory experience and make the interaction of the virtual world more real. In the dimension of emotional immersion, different tactile stimuli can evoke the corresponding emotional responses of players. Gentle touch feedback may bring reassurance and comfort, while strong impact feedback may trigger nervous thriller emotions. These emotional touches blend with the plot of the game, deepening the depth of emotional immersion of players.

Voice interaction technology focuses on cognitive and emotional immersion. In terms of cognitive immersion, voice commands simplify the game operation process, and players can easily obtain information and control the game process, so that they can devote more energy to the understanding and exploration of the game content. Taking large-scale VR open world games as an example, players quickly query task locations and item information through voice, which makes the game exploration process smoother and more efficient, and promotes cognitive immersion. At the emotional immersion level, voice interaction creates a more authentic social context, and voice conversations between players and avatars or other players enhance emotional communication. In VR games with rich stories, vivid voice interpretation makes the emotions of characters more easily perceived by players, stimulate emotional resonance, and enhance emotional immersion experience.

In terms of virtual-real fusion effect, motion capture technology is the core element of constructing accurate matching between virtual and real movements. It relies on a high-precision sensor system to accurately record the details of the players' actions in the real space, and is immediately converted into the actions of the characters in the virtual environment, whether it is a small hand movement or a large body

displacement, it can achieve almost no delay, no bias mapping, greatly improving the compatibility of virtual and real actions, making it difficult for players to distinguish between the two boundaries. For example, in VR simulation sports games, the player's movement posture is perfectly synchronized with the movements of virtual athletes, highlighting the key role of motion capture in the integration of virtual and real.

The contribution of haptic feedback technology to the virtual-real fusion effect is mainly reflected in enhancing the real texture perception of virtual objects. By simulating the tactile characteristics of different materials, such as the cold touch of smooth metal, the delicate friction of soft cloth, when players interact with virtual objects, they can truly feel the difference in the texture of the object, thus strengthening the real existence of virtual objects at the tactile level. In the VR object display application, the haptic feedback when users touch virtual exhibits makes them feel as if they are in a real exhibition environment and touch real objects, effectively improving the fidelity of virtual and real integration.

The role of voice interaction technology in virtual-real fusion is to enrich the interactive dimension and the authenticity of information transmission. In the multi-interaction system, voice commands make the player's interaction with the virtual environment more natural and smooth, as easy as interacting with people in the real world. For example, in the VR intelligent assistant application, players ask questions by voice, and the virtual assistant answers them by voice and provides corresponding visual information or operational guidance. This voice interaction method is combined with other interaction technologies, making the interactive response of the virtual environment more humane and realistic, and further improving the overall effect of virtual and real integration.

To sum up, motion capture, haptic feedback, and voice interaction technologies in multiple interaction mechanisms are intertwined and synergistic, establishing a close theoretical relationship with immersive experience and virtual-real fusion effect from different dimensions, which together constitute an important support system for users' deep experience and virtual-real fusion perception in VR games.

7. Optimization Strategies for VR Game Design and Development

7.1 Integration and Optimization of Interactive Technology

In the process of VR game design and development, attention should be paid to the integration and optimization of multiple interactive technologies. First of all, it is necessary to ensure the compatibility and collaboration between different interaction technologies to avoid technical conflicts or interaction faults. For example, in the development process, the interfaces of motion capture, haptic feedback and voice interaction need to be unified design and debugging, so that they can be seamlessly connected to achieve smooth interaction effects. Secondly, according to the type of game and the target user group, the application ratio and intensity of interaction technology should be reasonably configured. For example, for VR games based on action experience, such as fighting and sports games, we can focus on strengthening the application of motion capture and haptic feedback technology; For games that focus on narrative experience and social interaction, the proportion of voice interaction technology can be appropriately increased.

7.2 User Experience-Oriented Interaction Design

User experience-oriented interaction design is the key to improving the quality of VR games. When designing interactive functions, users' sensory needs, cognitive abilities and emotional expectations should be fully considered. From the perspective of sensory experience, it is necessary to carefully design the presentation of visual, auditory and tactile sensory stimuli, such as optimizing the resolution, color saturation, light and shadow effect of the game screen, improving the three-dimensional sense and fidelity of the sound effect, and enriching the types and intensity of haptic feedback. From the perspective of cognitive experience, it is necessary to design simple and clear game rules, task flow and interactive operation mode, so that players can easily understand and master the game content, and avoid cognitive overload caused by complex interaction design. From the perspective of emotional experience, it is necessary to pay attention to the writing of game plot, the shaping of characters and the creation

of emotional atmosphere, and guide players to have emotional resonance with game characters and plots through interaction design, such as designing interactive links such as voice dialogue and expression and motion capture with emotional appeal, so that players can get a richer and deeper emotional experience during the game.

7.3 Continuous Technological Innovation and Iteration

The VR game industry is in a stage of rapid development, and continuous technological innovation and iteration is a necessary means to maintain competitiveness. In terms of multiple interaction mechanisms, we should pay attention to the latest developments in relevant technologies, such as the research and development of new motion capture sensors, breakthroughs in more accurate haptic feedback technology and the emergence of more intelligent voice interaction algorithms, and promptly apply these new technologies to the design and development of VR games. At the same time, it is necessary to establish an effective user feedback collection and analysis mechanism, and iteratively optimize the game interaction design according to the user experience and demand feedback, and constantly improve the performance of multiple interaction mechanisms and user experience effects to adapt to market changes and the increasing expectations of players.

8. Conclusion

This study explores the impact of multiple interaction mechanisms on the enhancement of VR game users' high immersion experience and the effect of virtual-real integration. Based on the analysis of the current status of VR game interaction technology and the explanation of the theoretical basis of immersion and virtual-real integration, the action mechanism of multiple interaction mechanisms such as motion capture, haptic feedback and voice interaction in enhancing user immersion experience from sensory, cognitive and emotional dimensions is studied in detail. It also contributes to improving the matching degree of virtual and real actions and enhancing the perception of real texture of virtual objects. The empirical research method was used to verify the significant correlation between multiple interaction mechanisms and users' high immersion experience and good virtual-real integration effect, and the optimization strategy of VR game design and development was proposed, including the integration and optimization of interactive technology, user experience-oriented interaction design, and continuous technological innovation and iteration.

Future research can be further explored from the following directions. The first is to further explore the application characteristics and optimization strategies of multiple interaction mechanisms in different types of VR games (such as educational VR games, artistic creation VR games, etc.) to meet the needs of VR applications in different fields. The second is to study how to combine artificial intelligence technology with multiple interaction mechanisms, such as using artificial intelligence to achieve more intelligent interactive responses, personalized game experience recommendations, etc., to improve the intelligence level of VR games. The third is to deeply study the physiological and psychological impact of multiple interaction mechanisms on users' long-term use of VR games, such as whether it will lead to visual fatigue, cognitive overload and other problems, and explore corresponding prevention and mitigation measures to ensure the health and safety of users. Through continuous in-depth research, it is expected to provide more comprehensive and in-depth theoretical support and practical guidance for the sustainable development of VR game industry.

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