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ORIGINAL

FROM TRADITION TO MODERNITY: VIRTUAL REALITY-BASED EXHIBITION OF SPORTS PROJECTS ACROSS DIFFERENT HISTORICAL PERIODS

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ABSTRACT

The rapid development of virtual reality (VR) technology has introduced innovative possibilities for the digital preservation and dissemination of sports culture. This study explores the value and implementation pathways of VR technology in sports culture exhibitions by analyzing three representative cases: ancient Cuju, modern basketball, and contemporary skiing. It demonstrates how VR's characteristics of immersion, interactivity, and hyperreality can dynamically showcase the historical evolution and technical essence of sports culture. The findings reveal that VR technology, through realistic virtual scenes, dynamic timeline designs, and multi-sensory interactions, provides audiences with a deeply engaging experience that surpasses traditional exhibition formats, significantly enhancing the reach and cultural identity of sports dissemination. Additionally, the study identifies challenges such as hardware compatibility and user experience optimization in current VR applications. It suggests that future research should focus on the integration of VR with artificial intelligence and multi-sensory technologies to further enhance the immersion and personalization of cultural exhibitions. This research offers innovative theoretical and practical support for the digital preservation and global dissemination of sports culture.

KEYWORDS: Virtual Reality Technology; Sports Culture; Digital Preservation; Cultural Dissemination.

1. INTRODUCTION

The rapid development of virtual reality (VR) technology has injected significant innovation into cultural heritage preservation, virtual museum construction, and education. As a technology centered on immersive experiences, VR has revolutionized traditional cultural dissemination by leveraging high levels of interactivity and intuitive engagement (Lo et al., 2019). It enables users to transcend the constraints of time and space, allowing them to deeply perceive and understand the profound essence of culture. This technology exhibits vast potential in cultural exhibition and preservation, offering new possibilities for the integration of traditional culture and modern technology. In recent years, with the rapid advancement of scientific and technological capabilities, digital methods have been increasingly applied to the preservation of intangible cultural heritage. Particularly in the domains of ethnic culture and traditional sports, VR is regarded as a revolutionary tool that provides innovative pathways for the digital preservation and dissemination of culture(Ogrizek et al., 2024). In the fields of sports events and cultural exhibition, the effectiveness of VR technology has been particularly remarkable. For example, panoramic video technology allows viewers to immerse themselves in event scenes through a 360-degree perspective, significantly enhancing the sense of involvement and interactive experience (Cinnamon & Jahiu, 2023). In winter sports events, users can experience the dynamic visuals of skiing, ice hockey, and other activities from novel perspectives via VR devices, as though they are present at the event. This innovative format not only bridges the gap between audiences and sports culture but also opens new avenues for the global dissemination of sports culture. Meanwhile, VR technology has been employed in athlete training and referee decision-making, such as simulating real-world scenarios to improve training outcomes and the precision of referee judgments (Yunchao et al., 2023). Through such deep integration, VR not only serves event organizers and participants but also delivers novel interactive experiences to audiences and everyday users(Hutson & Olsen, 2022). Similarly, digital technology has demonstrated significant utility in the preservation of cultural heritage, especially in the transmission of intangible cultural heritage. The application of virtual exhibition technologies allows cultural content to be disseminated more vividly (Li et al., 2024). The construction of virtual museums dedicated to traditional sports culture is a prime example. This mode of virtually showcasing sports culture not only preserves valuable historical records but also enables users to directly experience the charm of traditional sports in a highly immersive manner. For instance, the Guangxi Ethnic Traditional Sports Digital Museum has established a regional sports database and leveraged VR scene display technologies to systematically preserve and widely disseminate sports culture (Lian & Xie, 2024). These virtual scenes allow viewers to fully explore the historical background, technical characteristics, and cultural significance of local sports projects, making them feel as though they are

actively participating on-site(Daniela, 2020). As a vital component of intangible cultural heritage, sports culture embodies rich historical memories and significant social value. The importance of its digital preservation and modernized display is increasingly evident. This approach not only provides new tools for cultural dissemination but also plays an active role in enhancing public cultural identity and awareness of preservation. As global cultural exchanges deepen, sports culture has transcended regional boundaries, becoming an essential bridge connecting diverse cultures (Rensmann, 2014). Through digital methods, sports culture can be preserved innovatively, offering contemporary audiences' opportunities to engage in cross-temporal dialogues with traditional culture. For example, the design of virtual museums enables traditional sports such as Cuju to be authentically recreated in virtual environments (Wilson, 2022), allowing users to experience the profound heritage and technical sophistication of ancient sports culture from a fresh perspective. This form of exhibition effectively enhances the participatory nature of cultural dissemination while inspiring public interest in cultural preservation. Nevertheless, the current digital display of sports culture faces significant challenges. Existing exhibition methods often lack sufficient immersion and interactivity, failing to meet user demands for deeper experiences (King et al., 2016). For instance, some virtual museums fail to incorporate user behaviors effectively, resulting in simplistic and less engaging interaction models. Additionally, the standardization of databases and exhibition content remains underdeveloped, limiting the systemic integration and presentation of content(Nicolescu, 2014). The breadth and diversity of sports culture, spanning extensive temporal and geographic dimensions, are difficult to fully capture with existing data integration and classification standards. Furthermore, many exhibition formats remain static or superficial, failing to explore the intrinsic and visual appeal of sports culture. For example, certain platforms rely solely on text and images without offering dynamic experiences or in-depth interactive designs (Levin, 2014). These issues indicate that current research has yet to develop comprehensive solutions for showcasing sports culture across historical periods. Against this backdrop, this study aims to construct a sports culture exhibition framework based on VR technology, covering different historical periods from traditional to modern sports. By integrating digital preservation and exhibition technologies, the framework seeks to dynamically present the developmental trajectory of sports culture, advancing its comprehensive protection and dissemination (Luther et al., 2023). This framework, combining cutting-edge digital technologies with traditional sports projects, overcomes temporal and spatial limitations, injecting new vitality into the transmission of sports culture. The study focuses on VR technology, incorporating interactive design, visual immersion, and cultural storytelling to explore the pathways for digitally showcasing sports culture from both technical and cultural dimensions (Liu et al., 2023). The significance of this

research lies not only in addressing existing gaps but also in providing theoretical and practical support for the digital preservation and dissemination of sports culture. Firstly, the proposed exhibition framework introduces an innovative approach to integrating traditional and modern culture. Through digital means, it preserves the heritage of sports culture, compensating for the shortcomings of traditional static exhibition methods in terms of both depth and reach. This VR-based method allows for a more comprehensive presentation of the historical value and cultural connotations of sports culture while opening new possibilities for its transmission through dynamic and immersive methods. Secondly, the immersive and interactive nature of VR technology attracts greater user participation, enabling them to deeply experience the unique charm of sports culture and thus enhancing cultural identity and preservation awareness. For instance, in a virtual environment, users can take on the roles of athletes, participating in traditional activities like Cuju or archery, not only learning their historical background but also experiencing their technical intricacies. This approach greatly elevates the participatory aspect of cultural dissemination to unprecedented levels. This study aims to establish a practice pathway that deeply integrates technology and culture, advancing the transmission and innovation of sports culture in the digital era. Through the application of VR technology, sports culture exhibitions are transitioning from static to dynamic, from one-way dissemination to multidimensional interaction. This technology-driven innovation not only provides new solutions for cultural heritage preservation but also opens new horizons for global sports culture exchange. As technology continues to evolve, the future of sports culture exhibitions will become increasingly intelligent and personalized, setting a new benchmark for the modernization of cultural preservation and dissemination practices.

2. Theoretical Foundation and Technical Framework

2.1 Theoretical Basis of Sports Culture Inheritance

Sports culture, as an integral part of human society, not only records the evolution of sports activities but also reflects the social landscapes, values, and cultural contexts of various historical periods (Maguire, 2000). From a historical perspective, sports culture has evolved from ancient rituals and competitions to modern sports, with its forms, functional values, and dissemination methods constantly adapting to societal changes. Ancient sports culture originated from human production and daily life practices, often characterized by ritualistic and competitive elements deeply intertwined with religion and ceremonial customs. For instance, Cuju, an ancient Chinese ball game, was not only a recreational activity but also a significant component of festivals and sacrifices. Sports in this period emphasized harmony between humans and nature, as well as collective honor and physical prowess. As society transitioned during the

Industrial Revolution, sports gradually detached from religious rituals, evolving into forms of leisure and social interaction. In modern times, sports culture has been profoundly shaped by globalization and technological advancements, developing into a multifaceted domain encompassing competitiveness, entertainment, and commercialization. The inheritance of sports culture also exhibits distinctive regional characteristics. Factors such as geographical environment, climate, and ethnic traditions have profoundly influenced the formation and evolution of regional sports cultures. For example, the cold climate of northern China facilitated the development of skiing and ice sports, while the rivers of the south gave rise to the unique tradition of dragon boat racing. These regional traits are not only evident in the forms of sports but are also deeply embedded in local cultural practices. Cuju, originating from Linzi in Shandong Province, exemplifies this interplay between sports and regional culture, as it reflects the cultural prosperity of ancient Qi and its integration into local rituals and social life. The transmission of sports culture relies on a combination of mechanisms. Traditional methods, including oral history, customary practices, and folk activities, form the foundation of cultural inheritance. In modern society, school education, media dissemination, and museum exhibitions provide new platforms for preserving and propagating sports culture.

Additionally, advancements in digital technology have injected fresh momentum into the process of cultural transmission. Virtual reality (VR) technology and digital museums offer immersive and interactive avenues for reintroducing traditional sports, preserving their historical value while creating opportunities for younger generations to engage with and learn about traditional sports culture. In summary, the transmission of sports culture is both a documentation of history and regional uniqueness, and a driver of cultural innovation and societal development. In an era of rapid technological advancements, exploring digital pathways for sports culture inheritance not only helps sustain cultural continuity but also fosters new opportunities for global cultural exchange.

2.2 Core Elements of Virtual Reality Technology

As an immersive technology, virtual reality (VR) is built on three core elements: immersion, interactivity, and hyperreality. These elements form the technological foundation of VR and determine its effectiveness in cultural exhibitions. In the digital presentation of sports culture, these key elements enable audiences to deeply engage with and comprehensively understand the essence of traditional culture, opening new possibilities for its dissemination and modernization. Immersion is a defining characteristic of VR technology, enabling users to fully enter a virtual world while "suspending" their perception of the real world. Through high-definition visual rendering, surround sound

effects, and real-time feedback, VR creates an experience akin to being physically present in the depicted environment. In cultural exhibitions, immersion provides users with an unparalleled "being there" experience. For instance, in sports culture presentations, VR allows users to participate in Cuju matches or experience winter sports from a first-person perspective, fostering a deeper appreciation of the cultural and historical significance of these sports. Interactivity distinguishes VR technology from traditional media by facilitating real-time interaction between users and virtual environments. This interaction can be achieved through controllers, voice commands, or full-body motion tracking. In sports culture exhibitions, interactivity allows users to actively "engage" in sports activities. For example, users can observe traditional sports matches and directly interact with virtual characters, even learning specific sports techniques. Such interactive experiences bridge the gap between users and exhibition content, significantly enhancing engagement and educational value. Hyperreality refers to VR's ability to create a virtual world that transcends the realism of the physical world, offering users more intricate and vivid experiences. In cultural exhibitions, hyperreality manifests not only in the faithful recreation of real-world scenes but also in the virtual reconstruction of historical settings.

For instance, VR technology can recreate ancient sports events that no longer exist or visualize cultural details that were not documented. Through high-quality graphic rendering and dynamic simulations, users can closely observe and experience traditional sports projects that were previously confined to historical records. In sports culture exhibitions, immersion, interactivity, and hyperreality complement each other to construct a rich user experience. For example, immersion allows users to enter a virtual Olympic stadium and feel the atmosphere of the event up close; interactivity enables users to "participate" in ancient Cuju matches, learning its rules and techniques; hyperreality provides detailed visual recreations of historical match scenes. This multidimensional experience not only enriches cultural exhibition formats but also offers a more vivid means of preserving and transmitting sports culture. In conclusion, immersion, interactivity, and hyperreality are the core elements of VR technology in cultural exhibitions. The integration of these three aspects in the digital presentation of sports culture significantly enhances user engagement and experience. It breathes new life into cultural dissemination while providing robust support for the preservation and inheritance of traditional sports culture.

2.3 VR Exhibition Model Design Framework for Sports Culture

The VR exhibition model for sports culture aims to dynamically present the historical evolution and diversity of sports culture through virtual reality technology. The core of this framework lies in classifying sports culture along

dimensions such as time, project characteristics, and regional culture. By doing so, it constructs exhibition solutions tailored to different historical periods and leverages immersive, interactive, and hyper realistic technologies to achieve modernized dissemination and preservation of sports culture. The time dimension serves as the central logic of the VR exhibition model. Sports culture can be divided into three key historical stages: ancient, modern, and contemporary. Ancient sports activities, such as Cuju and wrestling, often carried strong ceremonial and cultural symbolism. During the modern period, influenced by the Industrial Revolution, sports began to globalize and shift toward competitive formats. Contemporary sports, integrating technological innovation, have evolved into highly entertaining and commercially valuable activities. The VR model utilizes dynamic timeline-switching technology, enabling users in a virtual environment to intuitively perceive the transitions and developmental trajectory of sports culture across these distinct stages. In terms of content organization, the model incorporates two additional key dimensions: project characteristics and regional culture. The project characteristics dimension categorizes sports culture into competitive, ceremonial, and recreational activities. For example, Cuju is not only an ancient competitive sport but also rich in ceremonial culture. The regional culture dimension emphasizes the geographical and cultural context of sports projects, such as the prevalence of ice and snow sports in northern regions and dragon boat racing in southern areas. These classifications provide a solid foundation for the model's design content. From a technical perspective, the VR exhibition model achieves its core functionalities through several formulas:

Scene Construction: Scene construction is the foundation of the exhibition model, generating realistic historical scenes using virtual development tools. The design formula for scene construction can be expressed as follows:

$$S = \{L, A, E, T\} \tag{1}$$

where, S represents the virtual scene, L denotes the spatial characteristics of the scene, A signifies dynamic roles within the scene (e.g., athletes, spectators), E refers to environmental effects (e.g., lighting, weather), and T represents the time dimension, enabling dynamic switching of historical scenes. This formula allows the VR environment to visually, dynamically, and contextually reconstruct the historical nuances of sports culture.

User Interaction Design: The richness of user interaction design directly impacts the immersive experience. Users interact with the virtual scene using gestures, voice commands, or motion capture, with the interaction mapping relationship defined as:

$$M(u) = \sum_{i=1}^{n} w_i \cdot f_i(u) \tag{2}$$

where, $M(u)$ represents the interaction mapping between user actions and the virtual scene, $f_i(u)$ denotes the input functions of various actions (e.g., navigation, manipulation, selection), and w_i indicates action weights, which determine sensitivity and effectiveness. This formula enables users to interact with the virtual scene naturally and in real-time, such as participating in a Cuju match or controlling a dragon boat.

Immersion and Hyperrealism Effects: Achieving immersion and hyperrealism in scenes is a critical design goal for the model. Advanced physics engines and ray-tracing technologies are used to simulate realistic lighting and material reflections. The rendering formula can be described as:

$$R = \alpha \cdot P + \beta \cdot S \tag{3}$$

where, R represents the rendering outcome, P is light source intensity, S is the surface material reflectance coefficient, and α and β are weight parameters to balance visual effects and rendering performance. Hyperrealistic visual effects allow users to appreciate the intricate details and aesthetics of sports culture, enhancing the attractiveness of cultural dissemination.

Dynamic Content Integration: Integrating historical data and multimedia resources enables dynamic content updates in response to time and user demands. The formula for content integration is:

$$D = \bigcup_{t=1}^{T} \{H(t), C(t)\} \tag{4}$$

where, D is the displayed content, $H(t)$ represents the historical data t corresponding to a specific time point, and $C(t)$ signifies cultural contexts and visual elements. By utilizing this formula, VR systems can efficiently integrate cultural information across periods, providing users with diverse content experiences. In summary, the VR exhibition model for sports culture combines dimensions such as time, project characteristics, and regional culture to dynamically present and authentically restore cultural heritage. Through scene construction, interaction design, and immersive optimizations, the model enhances user engagement and participation while providing robust technical support for the digital preservation and dissemination of sports culture. This approach not only modernizes cultural presentation but also sets new benchmarks for integrating tradition with technological innovation.

3. VR-Based Historical Sports Project Display Model Design

3.1 Ancient Sports Project Display: The Case of Cuju

As one of the most iconic sports in ancient China, Cuju traces its origins back to the Warring States period and flourished during the Han, Tang, and

Song dynasties. This sport was not only a form of entertainment but also an integral part of ancient ceremonial culture. Recreating the historical context of Cuju through virtual reality (VR) technology allows not only the restoration of its technical aspects but also the exploration of its deep cultural significance.

Virtual Scene Design and Cultural Restoration: In the VR display, the scene is set in a typical Cuju playing field from the Song dynasty, such as a public square in a town center or a noble courtyard. Using high-precision 3D modeling, the virtual environment accurately restores ancient architectural styles, costumes, and game props. For instance, the players and audience are depicted wearing the flowing wide-sleeved robes distinctive of the Song dynasty, while the Cuju ball is designed as a leather sphere based on historical records. Dynamic elements are integrated into the scene to enrich the experience. These include the cheering sounds of the audience, interactive responses between spectators and players, and the collaboration and competition among the participants. Such details enable users to not only learn the rules of the game but also immerse themselves in the social atmosphere surrounding Cuju in ancient times.

Cultural Storytelling and Interactive Experience: The VR display emphasizes not only visual impact but also the narrative aspect to enhance cultural dissemination. Users can select virtual roles to enter the scene, learn the rules and techniques of Cuju, and experience the roles of ancient players. Additionally, the re-creation of specific historical events, such as the use of Cuju as a part of military training or as a competitive activity among nobles, offers users a more comprehensive understanding of its historical functions and cultural value.

Technical Implementation: The development of VR scenes relies on platforms such as Unity or Unreal Engine, employing real-time rendering technologies to ensure high-quality visual effects. Light-tracing techniques are incorporated to enhance the realism of the scene. The interaction design supports gesture recognition and voice commands, allowing users to control virtual characters with VR controllers to perform actions such as shooting and passing the ball. The database integrates historical records and visual materials of Cuju, dynamically loading relevant content through algorithms to provide users with an immersive learning experience. The platform offers not only a visual representation but also an interactive and educational approach to understanding Cuju.

Illustration: Figure 1 provides a conceptual visualization of a recreated Cuju goal scene, showcasing how VR technology can bring ancient sports to life.

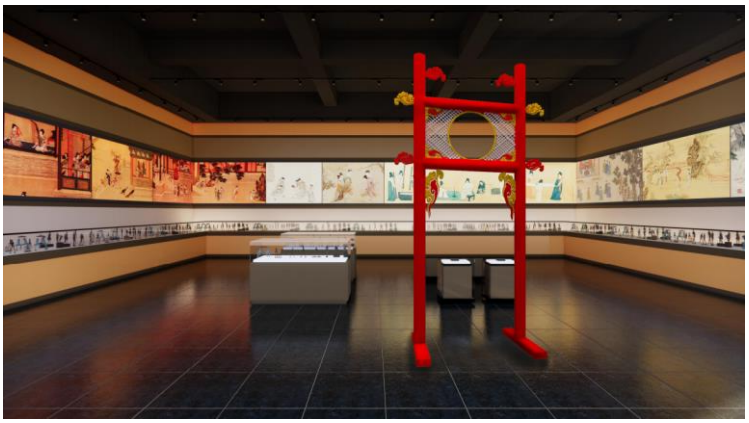

Figure 1: Illustration of Cuju Display Effect

This VR-based Cuju display serves as a powerful tool to bridge the past and present, allowing modern audiences to appreciate the technical sophistication and cultural richness of this ancient sport in an immersive and interactive way.

3.2 Modern Sports Project Display

In the exhibition of modern sports projects, tennis stands out as a sport with aristocratic origins that has gradually achieved global recognition. It illustrates the evolution from a leisure activity to a professional competitive sport. Through virtual reality (VR) technology, the origins, development, and technical advancements of tennis can be presented in a multi-dimensional and immersive manner, enabling viewers to experience its unique historical and cultural significance as well as its modern competitive appeal. The virtual scene design begins with the birth of the Wimbledon grass-court tennis tournament in the 19th century. This scene not only recreates the environment of tennis in its early days as a modern sport but also integrates period-specific costumes, equipment, and rules to showcase the distinct characteristics of early tennis matches. Wimbledon's iconic grass court is meticulously recreated using precise 3D modeling and lighting effects, vividly restoring the classic green lawn and surrounding spectator stands. Within this environment, users can take on the role of an early tennis player, wielding a wooden racket to compete against an opponent in a match adhering to 19th-century rules. This immersive experience allows users to understand early tennis regulations while appreciating the elegance and competitive spirit inherent to the sport. As the timeline progresses, the virtual scenes transition to tennis environments from the mid-20th century, such as the red clay courts of the 1920s French Open and the hard courts of the 1980s U.S. Open. Each scene showcases the technological advancements in tennis and the global expansion of the sport during these periods. Within these dynamic settings, viewers can observe how professional tennis evolved from an aristocratic pastime to a competitive event that captivates global audiences. Additionally, users can explore the

progression of tennis equipment, experiencing the transition from wooden rackets to modern carbon-fiber rackets, thereby gaining insight into innovations in materials and design. The interactive experience design serves as the core highlight of this exhibition. Within the virtual environment, users can directly participate in tennis matches, simulating strokes, serves, and volleys through motion capture devices. The system provides real-time feedback on shot angles, power, and accuracy, while offering suggestions to help users improve their techniques. Beyond matches, users can engage in training sessions within the virtual arena, learning basic tennis moves and advanced skills, such as spin serves and forehand-backhand combinations. This high level of interactivity not only enhances immersion but also makes the cultural and technical transmission of tennis more vivid and engaging. To emphasize the global influence of tennis, the virtual exhibition incorporates multimedia content, including replays of iconic matches and the career stories of legendary players. For instance, users can virtually "witness" the classic showdown between Björn Borg and John McEnroe at Wimbledon or relive the peak moments of Serena Williams' career in a dynamic virtual setting. Through a 360-degree panoramic view, users can not only watch the matches but also analyze players' strategies and techniques with pause and replay functionalities. On the technical front, the scene construction leverages high-performance virtual engines, utilizing ray tracing and dynamic rendering technologies to ensure accurate restoration of each historical phase. The movements of spectators, referees, and players within the scenes are dynamically simulated using AI and motion capture technologies, further enhancing realism and interactivity. Additionally, the database integrates multimedia resources on tennis history, including early tournament records, photographs, and videos of iconic moments. These resources are dynamically loaded based on user preferences, providing comprehensive informational experiences. The virtual display of modern tennis is illustrated in Figure 2.

Figure 2: Illustration of Modern Tennis Display Effect.

This VR-based virtual tennis display is not merely a recreation of the sport's history but a profound integration of culture and technology. By combining immersive interaction and multi-dimensional content presentation,

tennis, as a representative modern sport, is brought to life in a dynamic manner. Users can participate from a first-person perspective, experiencing both the technical intricacies and cultural significance of the sport. This form of exhibition not only holds significant value for the preservation of tennis culture but also opens new possibilities for the global dissemination of sports culture.

3.3 Modern Sports Project Display

In the exhibition of modern sports projects, skiing, a sport that combines speed and technique, embodies the unique charm of humanity's pursuit to challenge nature and integrate technology. Leveraging panoramic video technology, the digital display of skiing not only faithfully reconstructs skiing environments but also provides users with immersive viewing experiences and interactive participation opportunities. The virtual display is based on panoramic scenes of renowned skiing destinations, such as the snowy slopes of the Alps or the ski venues of the Winter Olympics. Using multi-camera setups, panoramic video technology captures 360-degree perspectives of the slopes, the movements of skiers, and the surrounding natural environment. When wearing VR equipment, users can "enter" the ski slopes from a first-person perspective. Whether it is the thrill of leaping over obstacles or the dynamic sensation of rapid descents, users are fully immersed in the allure of skiing. The scene design highlights the diversity of skiing activities, ranging from competitive events like alpine downhill and snowboarding to recreational skiing projects like freestyle skiing. Each scene is rendered with high fidelity to reflect real geographic environments, including the slope gradients, trail markers, and weather conditions. Sound simulation technologies, such as wind noise and the friction of skis on snow, further enhance the user's immersive experience. To increase interactivity, the panoramic video display incorporates multiple participation modes. Users can choose to observe as spectators, switching perspectives to watch skiers' movements and entire races, or even "follow" a skier's trajectory in real time to experience their speed and techniques. Alternatively, users can take on the role of a skier in virtual skiing competitions. By using controllers or motion capture devices, users can control the direction, speed, and jumps of their virtual skis. The system calculates scores in real time based on user performance and provides technical feedback, such as optimal turning angles and aerial posture suggestions, allowing users to enjoy the challenge of skiing techniques. The display also includes a skiing technique tutorial module. Users can select the "beginner mode" to learn basic movements like starting, turning, and braking, or progress to the "advanced mode" to practice sophisticated techniques like rotational jumps and obstacle course challenges. During the tutorial, panoramic video technology employs slow-motion playback and step-by-step explanations to help users grasp key movements. Additionally, the virtual display module for skiing equipment enables users to gain a deeper understanding of the structure and functions of

skis, boots, and protective gear, preparing them for real-world skiing. To reinforce its educational value, the display incorporates content on skiing culture, such as the origins of the sport, its introduction to the Olympics, and advancements in skiing technology. Within the virtual environment, users can access interactive panoramic video touchpoints to watch iconic moments in skiing history, such as the introduction of skiing at the 1960 Winter Olympics or the impact of modern high-tech equipment on skiing speeds. Technologically, the panoramic video relies on high-resolution cameras and dynamic rendering engines, capturing ski scenes in 8K or higher resolutions. Panoramic stitching technology and ray-tracing algorithms ensure that every frame has authentic spatial depth and visual impact. To support interactivity, the system integrates real-time feedback modules, synchronizing users' movements and operations with the virtual skier in the panoramic video, creating a seamless and fluid experience. The modern skiing display is illustrated in Figure 3.

Figure 3: Illustration of Modern Skiing Display Effect

This use of panoramic video technology to showcase skiing not only dynamically and immersively presents the charm of modern skiing but also combines interactivity and educational design to integrate the dissemination of sports culture with personal skill development. While experiencing the speed and techniques of skiing, users also gain insight into the spirit of human exploration and the cultural significance behind the sport. This innovative display model sets a compelling benchmark for the digital dissemination of modern sports projects.

4. Discussion

Virtual reality (VR) technology has brought a new vitality to the exhibition of sports culture. Its unique features of immersion and interactivity have significantly enhanced both the breadth and depth of cultural dissemination. In traditional exhibitions, audience engagement often relies heavily on text and images. However, VR technology allows users to "enter" the cultural context through highly realistic virtual scenes. For instance, users can immerse

themselves in an ancient Cuju match or experience the dynamic atmosphere of an Olympic skiing event. This sense of being physically present transcends the limitations of traditional exhibition formats, greatly enhancing the audience's perception and understanding of cultural elements. Additionally, VR technology integrates dispersed sports cultural resources into a systematic display. Through dynamic timelines, it presents the historical evolution of sports culture across various periods, enabling viewers to gain a comprehensive understanding of cultural diversity and transmission. This approach not only enriches the forms of cultural presentation but also deepens the resonance and recognition of cultural heritage among audiences. Despite the notable achievements of VR technology in the exhibition of sports culture, its widespread adoption faces several technological and practical challenges. One of the primary issues is technological compatibility. Variations in device performance and adaptability result in inconsistent user experiences. For example, low-end devices may not support high-quality rendering, thus diminishing the sense of immersion. Furthermore, the public's acceptance and familiarity with VR devices remain limited. Many people perceive VR primarily as an entertainment tool, overlooking its profound potential for cultural dissemination. Consequently, the current applications require further refinement in terms of hardware compatibility and user education. To address these challenges, future technological advancements should focus on optimizing compatibility across devices and enhancing user experiences. By improving software algorithms and hardware adaptability, VR content can achieve consistent performance on a range of devices. Additionally, reducing the complexity of user operations is essential. This can be achieved by developing simpler control interfaces or incorporating voice and motion capture technologies, enabling users to interact with virtual environments naturally. Further promotion efforts, such as educational campaigns and trial experiences, could help more people appreciate the unique value of VR in cultural dissemination, thereby accelerating its broader adoption. In future research, the integration of VR with artificial intelligence (AI) will be a key direction. Through AI, systems can dynamically adjust content based on user behavior and preferences. For example, if a user lingers in a virtual scene for an extended period, the system could proactively provide relevant background information or suggest related experiences, enhancing both immersion and learning outcomes. Moreover, the development of multi-sensory interaction will open new possibilities for the exhibition of sports culture. Beyond visual and auditory integration, technologies involving touch and smell will provide users with a more authentic and multidimensional sensory experience. For instance, in a skiing scenario, tactile devices could simulate the friction between skis and snow, while olfactory technology could recreate the fresh scent of snow, offering users a more comprehensive encounter. The continuous innovation of VR technology presents unprecedented opportunities for the preservation and

dissemination of sports culture. From enhancing immersion and interactivity to realizing personalized recommendations and multi-sensory integration, technological advancements are steadily expanding the boundaries of cultural exhibition. Future research should further explore the deep integration of cross-disciplinary technologies, optimizing user experiences and enhancing content presentation to unlock new possibilities for the transmission and innovation of sports culture. VR technology is not just a tool for displaying sports culture; it is a bridge that enables audiences to establish profound connections with history and culture, providing an innovative solution for the global dissemination of cultural heritage.

5. Conclusion

The rapid advancement of virtual reality (VR) technology has opened up new possibilities for the preservation and dissemination of sports culture. As a highly immersive, interactive, and hyper realistic digital tool, VR transcends the limitations of traditional exhibitions by presenting the historical evolution and technical essence of sports culture in a vivid and intuitive manner. This study explored the value and implementation pathways of VR technology in showcasing sports culture, spanning different historical periods from ancient to modern times, using case studies such as Cuju, basketball, and skiing. It demonstrated how VR reshapes the relationship between audiences and sports culture. Firstly, VR technology employs realistic virtual scenes and dynamic timeline designs to enable users to "travel through" history and deeply experience the ritualistic essence of ancient sports, the globalization of modern sports, and the technological and cultural integration of contemporary sports. This approach not only broadens and deepens cultural dissemination but also significantly enhances user engagement and cultural identity. Secondly, the interactive nature of VR provides users with novel role-playing experiences. Whether participating in an ancient Cuju match or tackling the challenges of modern skiing, users can deeply engage with the unique charm and technical sophistication of sports culture through virtual environments. However, current applications of VR technology in sports culture exhibitions face limitations such as insufficient hardware compatibility and high operational complexity for users. In the future, with continued technological advancements, optimizing hardware compatibility, simplifying operations, and enhancing user education will become key developmental goals. Furthermore, integrating VR with artificial intelligence (AI) and multi-sensory interaction technologies holds the potential to enhance the immersion and personalization of cultural exhibitions, thereby creating more opportunities for the preservation and transmission of sports culture. In conclusion, the application of VR technology not only provides innovative methods for exhibiting sports culture but also drives a transformation in cultural dissemination, allowing traditional sports culture to transcend time and space while deeply integrating with modern technology. As technology matures and

adoption becomes more widespread, the digital preservation and dissemination of sports culture will enter a new era of expansive growth. VR technology will establish a global bridge for cultural exchange and understanding. This deep fusion of technology and culture not only ensures the continuity of historical memory but also contributes fresh vitality to the protection of cultural diversity worldwide.

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