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Analysis of Immersive Exhibition Based on Glasses-free 3D Technology

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Abstract: This article primarily examines glasses-free 3D technology and its application in immersive exhibitions. The article includes an analysis of glasses-free 3D technology and its applications, an examination of immersive exhibitions supported by glasses-free 3D technology, as well as the drawbacks of glasses-free 3D technology and its future development trends. It is hoped that this analysis can offer some insights into the prudent application of glasses-free 3D technology, aiming to achieve a compelling immersive exhibition experience.

Keywords: Glasses-free 3D technology; Immersive exhibition; Augmented reality; Multimedia interaction

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1. Introduction

With the continuous development and innovation of modern science and technology, an increasing number of advanced technologies are being widely utilized in exhibition work. Particularly, glasses-free 3D technology has emerged as a significant advantage in application. To achieve a compelling immersive exhibition effect, researchers and technicians must intensify their research into the application of glasses-free 3D technology, thereby enhancing the exhibition experience for the audience [1]. As an emerging advanced technology, glasses-free 3D technology not only delivers a striking visual impact to the audience but also immerses them in the experience. During exhibition activities, the unique advantages of glasses-free 3D technology enable visitors to seamlessly integrate into the exhibits, experiencing a heightened sense of realism. Glasses-free 3D technology serves as a medium of artistic expression utilizing light, with its production method closely resembling that of projection technology [2].

2. Analysis of glasses-free 3D technology and its applications

2.1. Basic overview of glasses-free 3D technology

Glasses-free 3D technology refers to an advanced technology capable of achieving stereoscopic viewing effects without the need for polarized glasses. The primary principle of this technology involves displaying real scenes

on a screen using interaction and projection technologies [3]. Its core components mainly include lenticular lens technology and light barrier technology. Lenticular lens technology primarily utilizes lenticular lenses to magnify images and project specific light into the human eye. This process expands the image and utilizes the different areas perceived by the human eye to determine the image's distance. Additionally, holographic technology serves as another method to achieve glasses-free 3D effects. This technology utilizes the principles of light interference and diffraction to record image information within a holographic medium. Subsequently, it presents a three-dimensional image when exposed to an appropriate light source [4].

2.2. Application status of glasses-free 3D technology

With the continuous advancement of glasses-free 3D technology, its application scenarios are becoming increasingly diverse. Currently, this technology is not limited to indoor displays but is also extensively used in outdoor displays, showcasing remarkable application effects. Glasses-free 3D technology has garnered significant attention in the projection field due to its numerous advantages, including simple and convenient operation, impressive visual effects, and immersive experiences. It has become one of the most sought-after technologies in digital multimedia art exhibitions [5]. For instance, in multimedia interactive exhibition halls, holographic display cabinets, and phantom imaging systems utilize glasses-free 3D technology, enabling users to view three-dimensional images through specialized devices. Corporate exhibition halls utilize glasses-free 3D holographic projection to showcase product information, while museums use holographic images to depict historical narratives. Moreover, large folding LED screens integrated with glasses-free 3D technology adorn the exterior walls of buildings, serving as city landmarks that attract significant attention and fulfill publicity purposes. In modern stage performances, gauze projection techniques emulate the effects of glasses-free 3D holographic projection, enhancing the overall simulated spatial experience in collaboration with stage actors [6].

3. Analysis of immersive exhibitions supported by glasses-free 3D technology

Based on current immersive art exhibition activities, the primary application strategies of glasses-free 3D technology include the following: first, enhancing the experience of multiple scenes; second, improving the augmented reality visual effect; third, enhancing the multimedia interactive experience; fourth, creating immersive artistic expressions. The following is an analysis of the specific application strategies of this technology.

3.1. Provide multi-scenario three-dimensional or multi-dimensional visual effect

Glasses-free 3D technology primarily relies on interactive and projection technologies to project real-world scenes onto screens, creating a three-dimensional, multi-dimensional space for the audience, thus offering a diverse viewing experience. Outdoor 3D display screens have emerged as a popular choice in advertising media, seeing widespread use in building exterior wall displays both domestically and internationally in recent years [7]. Outdoor glasses-free LED displays typically feature curved right-angle screens. The audience can position themselves in alignment with the curvature for optimal visual effects. For instance, the large-scale media wall "Wave" in South Korea's Times Square consists of a massive 80 m wide and 23 m high LED display screen. Through the judicious application of glasses-free 3D technology, it simulates turbulent and rolling waves accompanied by corresponding audio, delivering an impactful visual experience to passersby [8].

Another notable example is the series of exhibitions featuring digital artworks titled "Eternal Life" by Bulgarian artist Stoyan, primarily displayed at international airports across multiple countries. These works employ glasses-free 3D displays to explore the dimension of time and express the artist's reflections on

the relationship between life, society, and nature. Through the seamless integration of eternal motion and static geometric elements, the exhibition creates a more realistic, vivid, and artistically compelling viewing experience for the audience.

The implementation plan of the glasses-free LED display mainly comprises three components: a computer, a video processor, and an outdoor LED display control system. The 3D video source is transmitted to the LED display screen through the video processor to achieve a point-to-point, undistorted three-dimensional virtual imaging effect.

First, the 3D video source is imported into the computer via a USB flash drive or network. The computer receives and stores the video information, then transmits it to the video processor through LED display playback software. Subsequently, the video processor receives the video information from the computer, interprets and transforms it into a format that the LED display can receive, and sends it to the terminal display. Specifically, the pixels on the large screen are initially divided into two groups, left and right, using raster technology. When viewed by a person's left and right eyes, they perceive two sets of pixels on the left and right, resulting in parallax [9]. Secondly, through sub-pixel technology, each pixel is divided into multiple sub-pixels, enabling the left and right eyes to perceive different sub-pixels of the same pixel as distinct objects, thus creating a three-dimensional effect. Thirdly, special algorithm processing and optimization are conducted based on factors such as the resolution, size, angle of folding, distance, and position of the large screen. This ensures the generation of specific video source materials tailored to the glasses-free 3D large screen, thereby maintaining consistency in image quality and visual experience [10].

This exhibition mode not only provides the audience with a genuine sense of presence but also enhances their understanding and perception of the interaction between the exhibition and its surrounding environment. It enables the audience to experience the inherent connections and external influences among art, individuals, and the environment.

3.2. Augmented reality mode in glasses-free 3D effects

There are currently three main types of augmented reality technology: content augmented reality technology, interactive augmented reality technology, and space augmented reality technology. The primary application strategy of this technology involves adding virtual content to the real world based on the user's specific requirements. Users can utilize corresponding equipment to interact with the virtual scene [11].

The principle of augmented reality technology lies in capturing real-world information through sensors, utilizing computer vision algorithms to identify and comprehend the real-world environment, and then superimposing virtual information onto the real world. This process ensures alignment between the virtual information and the real-world environment through tracking and calibration. Subsequently, the interaction between users and augmented reality content is realized through user interaction [12]. The basic principles encompass five components: sensor technology, computer vision, virtual information superposition, tracking and calibration, and user interaction.

For instance, American digital artist Marpi creates interactive, scalable, and multi-platform artwork, allowing individuals to shape and create their pieces. He has designed and built various interactive installation cases for digital ecosystems, with one of the most notable being "Binary Garden." This is a multi-user, remote-controlled, real-time interactive digital device. Anyone can engage with this system via a smartphone and web browser, without the need for additional applications or technologies like Bluetooth or Wi-Fi. The essence of this work lies in its use of AR technology to blend the virtual ecosystem with reality, offering a novel interactive experience. Within this ecosystem, procedurally generated walking creatures continuously evolve, ensuring

each interaction is a unique artistic experience.

Additionally, some artists utilize AR technology to "remix" classic artworks, breathing new life into timeless pieces. This application revitalizes classic works, activating them through audience engagement and integrating them into our world in fresh forms [13]. This not only transforms museum visits into enchanting exploratory experiences but also imbues the artwork with added layers and connotations.

3.3. Enhance multimedia interactive experience through glasses-free 3D technology

In immersive art exhibitions supported by glasses-free 3D technology, multimedia interaction stands as the most crucial feature. This interaction utilizes 3D imaging technology to project corresponding scenes onto screen devices, engaging with the audience based on scene requirements and feedback to establish a novel interactive model. With the ongoing development and innovation of glasses-free 3D imaging technology and VR technology in recent years, glasses-free 3D immersive art exhibitions have evolved to offer audiences not only access to virtual worlds but also interaction with various objects or scenes within these virtual environments [14].

For example, the globally popular "Van Gogh's World" panoramic digital art interactive exhibition commenced its global tour in 2022. The organizer, Global Dream, incorporates multimedia interactive technology alongside glasses-free 3D technology. The exhibition hall spans a dreamy light and shadow space of up to 400 square meters, comprising 9 dynamic multimedia art display areas and 4 interactive areas. These areas feature wall interaction, ground interaction, augmented reality, immersive folding screen projection, and phantom imaging technology. By integrating real scene restoration with sound, light, and electricity, the exhibition not only delivers a stunning multimedia interactive experience but also provides audiences with a deeper understanding of the stories and emotions behind each of Van Gogh's paintings.

3.4. Create immersive artistic expressions through glasses-free 3D technology

In the process of art exhibitions through glasses-free 3D technology, immersion is made by the support of glasses-free 3D technology, making the audience feel as if they are actually there. For instance, the combination of 360° surround screen projection with a ground interactive system and dome projection can project real scenes onto the screen, creating an immersive viewing experience. In this context, glasses-free 3D technology has emerged as the quintessential form of immersive artistic expression in modern art exhibitions.

For instance, in the "Time and Space Tunnel" immersive art exhibition held in Beijing Chaoyang Park in 2019, from September 27th to October 1st, the organizers effectively employed augmented reality within glasses-free 3D technology. Utilizing 360° surround screen projection technology, a virtual reality scene depicting travels through time and space was created for viewers. Through the ring-screen projection system, the audience was immersed in a virtual digital simulation world, enabling them to uncover hidden content in the virtual scene by scanning with their mobile phones. This approach provided the audience with an immersive viewing experience, stimulating their curiosity and desire to explore and acquire knowledge, ultimately achieving an interactive viewing effect.

4. Disadvantages of glasses-free 3D technology and its future development trends

4.1. Disadvantages of glasses-free 3D technology

As a new multimedia display technology that has emerged in recent years, glasses-free 3D technology is highly suitable for modern immersive art exhibitions. However, judging from the practical application of this technology, it still has some disadvantages. These mainly include the following aspects.

(1) This technology demands extremely high requirements for supporting equipment, with practical

applications often requiring a significant investment in technology and equipment costs. (2) The production of art exhibition works supported by this technology is a comprehensive project involving various contents, technologies, and methods. Any issues in any part of the process can hinder the completion of such works [15]. (3) This technology necessitates high levels of professionalism from creators. During the production process, creators must not only possess a deep understanding of the relevant knowledge and technology but also need to be proficient in operating various related software. (4) Creating immersive art exhibitions supported by glasses-free 3D technology is a highly creative endeavor that requires substantial manpower, equipment, and time. Additionally, in some interactive projects, the number of viewers needs to be controlled, which significantly reduces the project's profitability. (5) Visual fatigue: Prolonged viewing of glasses-free 3D content may cause visual fatigue. This is because the 3D effect requires constant adjustment of focus and angle, increasing the strain on the eyes. (6) Resolution and brightness limitations: Glasses-free 3D technology may face limitations in resolution and brightness when achieving 3D effects. This can result in reduced image quality or dimmer displays, impacting the viewer's experience. (7) Content restrictions: Currently, there are relatively few film sources available for glasses-free 3D technology, limiting its application and development. Although more 3D content will likely be produced and released with the continuous advancement of technology, there are still deficiencies in both the quantity and quality of content.

4.2. Future development trends of glasses-free 3D technology

Based on the analysis of the main application disadvantages of glasses-free 3D technology presented above, researchers and technicians should combine these insights with specific applications and research to reasonably analyze the future development trends of glasses-free 3D technology. From the current standpoint, the main development trends of this technology should include the following aspects. (1) Conduct scientific research on supporting equipment for this technology. By introducing more advanced technologies and utilizing alternative equipment, the cost of supporting equipment application can be effectively reduced. (2) Increase efforts in researching glasses-free 3D and other related technologies. Resolve technical challenges in the production process of such works through continuous technological development and innovation. (3) Build upon the main applications and development directions of glasses-free 3D technology to cultivate more professional technical talents. This will provide human resource support for the application of this technology and the production of its works. (4) Reasonably introduce artificial intelligence design, operation, and other technologies into the design work of such art exhibitions. This can save manpower, equipment, and time costs and appropriately reduce the rigid requirements for the number of visitors in interactive art exhibitions. This will promote the innovative application of glasses-free 3D technology in modern immersive art exhibitions.

5. Conclusion

In summary, glasses-free 3D technology currently represents the most advanced and typical multimedia, digital, and information display technology. When properly integrated into art exhibitions, this technology can offer audiences an immersive viewing experience, enhancing the exhibition's appeal and delivering exceptional visual effects to viewers. To achieve this objective, researchers and technicians must possess a comprehensive understanding of glasses-free 3D technology and then apply it judiciously to meet the specific requirements of contemporary immersive art exhibition activities. Through this approach, the full potential of glasses-free 3D technology can be realized, providing robust technical support for immersive art exhibitions and fostering their positive development.

Disclosure statement

The author declares no conflict of interest.

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