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Research on the Application of Digital Design in Museum Design

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Abstract: This study aims to explore how digital design innovates museum design concepts, exhibition methods, and visitor experiences, driving modernization and enhancing educational functions. By analyzing the principles of digital technologies such as virtual reality (VR), augmented reality (AR), and interactive design, along with their specific applications in museums, and through case studies, it is found that digital design significantly enhances museums' educational functions and cultural value, providing more intuitive and in-depth historical and cultural interpretations while improving operational efficiency and visitor satisfaction. The findings indicate that digital design is profoundly transforming museums, not only enriching exhibition methods but also deepening visitor engagement and experience, making it a key trend for future museum development. However, challenges such as balancing tradition with modernity, physicality with virtuality, and addressing the continuous learning demands brought by technological advancements still require further research.

1. Overview of Digital Technology

1.1 Virtual Reality (VR)

Virtual reality (VR) is a cutting-edge technology that utilizes computer-generated environments to immerse users in artificially constructed three-dimensional worlds. By wearing VR helmets or using other wearable devices, users can experience highly simulated visual, auditory, and even tactile experiences, as if they are in another reality. The key to this technology lies in its powerful graphics processing capabilities and precise motion tracking system, which work together to enable real-time synchronization of virtual environment responses with user actions. VR is gradually demonstrating its irreplaceable value in multiple fields such as gaming, education, psychotherapy, and engineering design. For example, in the game, players can personally experience the perspective of their characters and enjoy an unprecedented immersive experience; In the field of education, VR can simulate various complex scenes, such as historical event scenes, biological structure observations, etc., greatly enriching the learning experience.

Virtual reality (VR) technology has brought revolutionary changes to museum design, as it can not only reconstruct historical scenes, but also allow visitors to explore places that cannot be physically accessed in person. Through VR, museums can create a digital exhibition space that allows artworks, artifacts, and even entire buildings to be 3D reproduced. By wearing a VR helmet, users can freely walk in the virtual environment, observe every exhibit up close, and even touch and

interact. This immersive experience not only increases the fun and participation of visiting, but also solves the problems of spatial limitations in physical museums and the protection of precious cultural relics. For example, for historical sites or damaged artworks, VR can restore their original appearance, vividly reproduce historical stories, and perfectly combine education and entertainment.

1.2 Augmented Reality (AR)

Augmented reality (AR) is the process of overlaying virtual information onto the field of view of the real world. Unlike VR, this technology does not create a completely new environment, but rather integrates virtual elements into the user's current environment through devices such as phone screens and smart glasses. The key technologies of AR include precise location tracking and image recognition, which ensure that virtual information can be accurately located and seamlessly integrated with real scenes. The application scenarios of AR are very extensive, from virtual fitting rooms and product previews in the commercial field, to interactive textbooks and virtual experiments in the education field, to maintenance guidance, real-time navigation and other fields. AR can provide unique value in enhancing user experience. For example, AR can provide consumers with a "try first, buy later" shopping experience, or provide real-time guidance and assistance to engineers during complex mechanical repair processes.

Augmented reality (AR) technology plays an innovative role in museum design, providing visitors with a richer and more personalized experience by overlaying virtual information in the real world. In museums, AR can be used to enhance the information display of exhibits. With just a smartphone or specialized AR glasses, visitors can see the stories behind the exhibits, the creative process of artists, or the historical background of cultural relics. In addition, AR can also be used to create interactive games, encourage visitors to actively participate, and improve learning efficiency. For example, an exhibition about the dinosaur era can use AR technology to bring stationary fossils to life, showcasing the dynamic image and ecological environment of dinosaurs, greatly enhancing the attractiveness and educational value of the exhibition.

1.3 interaction design

Interaction design is a bridge that connects people and technology, focusing on designing user interfaces for products, systems, or services to ensure that users can easily and intuitively interact with them. It involves a deep understanding of users' needs, behaviors, and motivations, creating both aesthetically pleasing and practical interactive experiences through carefully designed interfaces and operational processes. The core principles of interaction design include user centered design, usability of interfaces, timely feedback, and flexibility and control. The design process typically includes stages such as research and analysis, ideation and prototyping, testing and iteration to ensure that the final product truly meets user needs and provides a smooth and efficient user experience. Interaction design is one of the key factors determining the success or failure of websites, mobile applications, and more complex systems and services. For example, when designing a mobile application, the interaction designer will consider how to optimize the user interface to comply with ergonomic principles and provide clear operational guidance, thereby enhancing the user experience.

Interaction design is crucial in museum design, as it focuses on how to enhance the overall experience of visitors through user-friendly interfaces and operational processes. The role of interactive design is particularly evident in the museum's navigation system. Designers need to consider the audience needs of different age groups and cultural backgrounds to ensure the readability and comprehensibility of information. Modern museums often use multimedia terminals,

interactive booths, or mobile applications as navigation tools. Through interactive design, these tools can provide functions such as multilingual explanations, personalized route recommendations, and in-depth interpretation of exhibits. For example, an interactive booth can allow users to choose a specific themed tour route, while providing virtual tour guide services that automatically adjust the content according to users' interests, making each visit a unique exploration journey. Through these carefully designed interactive elements, museums can not only better tell the stories of their collections, but also stimulate visitors' curiosity and promote cultural inheritance and exchange.

Different types of museums have different types of interaction methods (Table 1).

Table 1 Interaction Design of Different Types of Museums

Types of useums	Interactive Methods	Interactive Focus
History	Historical Reproduction and Role Playing	Immersive Historical Experience
Arts	Artistic creative interaction and artistic experience	stimulate artistic inspiration and imagination
Natural category	Interactive and exploratory learning in natural science	popularization enhances the fun of natural science knowledge
Technology	Interactive display and experience of technology,	science popularization, and exploration of technology knowledge and interaction

2. Overview of Digital Display Design

2.1 Digital Display Design

Digital exhibition design refers to the use of information technology tools, such as computer technology, to digitize physical museum exhibits and combine them with exhibition design to achieve exhibition purposes. With the application and promotion of digital information technology, traditional museum exhibition methods are no longer accepted by the public. People are trying to break away from traditional exhibition methods, and digital exhibition experience design is following the trend of the times and can meet the needs of the development of the times. The amount of information conveyed by existing digital information technology has far exceeded traditional displays, with characteristics such as diversification, convenience, humanization, and interactivity, catering to the demands and characteristics of information intake in the digital age.

2.2 Digital Display Design Features

2.2.1 Humanize the display concept

Most museums today are facing the problem of homogenization, with a single exhibition method that displays items through glass cabinets and introduces them through display boards. It is even difficult to distinguish the differences in content between museums in different places. Specialized vocabulary and simple introductions cannot help us deeply understand the content. When faced with an entire exhibition hall, it is easy for visitors to feel bored and unable to accept all the exhibition cultures in a short period of time, blindly displaying for the sake of display, ignoring the visitors' visiting experience. In order to stimulate users' enthusiasm and participation, the design of interactive experience during the display process has become particularly important.

The process of the digital age has driven the development of emotion recognition systems, which can constantly monitor users' emotional changes and provide designers with a large amount of data.

In museum design, changes in users' emotions are very important, and even the emotional fluctuations of users throughout the entire exhibition path require designers to think about. Applying emotion recognition systems to modern museum design, through data feedback, design adjustments and transformations can be made to achieve a better visiting experience, which also promotes personalized customization design.

2.2.2 Diversified display methods

The exhibition content of museums covers a wide range of topics, including cultural history, dietary customs, natural world, and other comprehensive knowledge, making the exhibition methods of museums diverse. The key to modern museum design is to stimulate users' participation, experience, and fun through human senses such as vision, touch, and smell.

(1) Emotional Interaction

Interaction, to some extent, can be referred to as' interaction '. The interaction concept of interaction in the museum includes the interaction between people, space and exhibits, including human-computer interaction. The increasingly mature design based on emotional interaction system, the development of Internet technology, emotional computing, intelligent identification technology, wireless network, micro sensors and physiological signal recording equipment, make the gap between the input and output of human-computer interaction smaller and smaller [6]. From a physiological perspective, the direct manifestation of human emotional experience is the sensory experience of objective things. Based on the five senses, the perception of things constructs a rich emotional experience for psychology. Interaction design aims to meet the emotional needs of users, which is crucial for museum design. The purpose of museums is to achieve information dissemination and communication, and interactivity can enhance the audience's sense of experience, stimulate their exploratory desire, meet their emotional needs, and actively receive the information that museums want to display and convey.

(2) Virtual Immersion

Based on the development of virtual reality technology, a virtual experience environment with "real" visual, auditory, and tactile effects can be created, allowing viewers to "truly" immerse themselves in the artistic atmosphere created by designers for immersive interactive experiences. The advancement of this technology can make the display content in the exhibition area more realistic and vivid, while enhancing visitors' sensory experience of the exhibits. Breaking the traditional static exhibition method of using text display boards and commentators to explain in museum exhibition areas, allowing viewers to experience a sense of immersion and bringing the originally dull and rigid museum to life.

Through the design concept of combining reality and virtuality, museum design can be made more flexible, space expression more rich, and imaginative. At the same time, based on technological innovation, emotional interaction systems can provide statistical feedback on user preference data, which can provide personalized customization for visitors and enhance their visiting experience.

(3) Game participation

Games have become an important part of our modern lives. In an unfamiliar environment, games can help us quickly integrate into the environment, improve our social skills, and enhance the interaction between people. Games can be said to be the most participatory activity. Injecting the information that museums need to convey into the process of games can make people accept and absorb it more quickly. At the same time, this greatly increases people's experience and enriches emotional changes.

3 Application of Digital Display Experience Design in Museum Display

3.1 Scenario based design

Scene based design plays a core role in the digital exhibition experience of museums. By constructing specific historical, cultural, or artistic scenes, it allows audiences to immerse themselves in the stories and emotions behind the exhibits, thereby gaining a deeper and richer visiting experience. The following are several application methods of scenario based design in digital display:

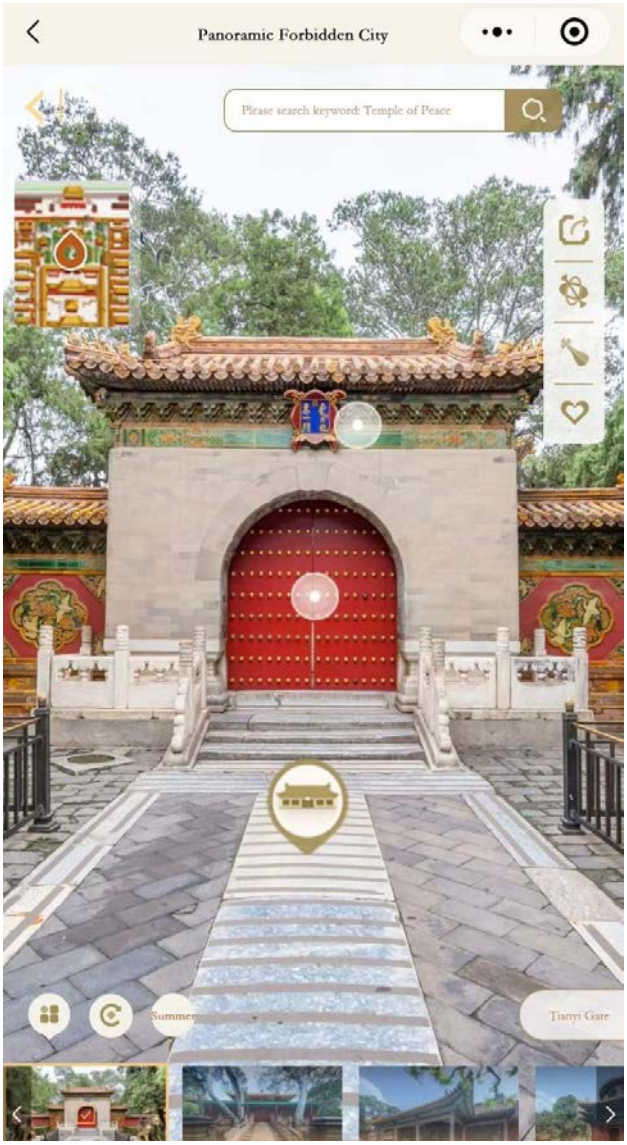

Figure 1: Panoramic View of the Palace Museum

3.1.1 Interactive narrative scenes

By utilizing multimedia technology and interactive installations, museums can create a series of interactive narrative scenes. For example, in an exhibition of ancient civilizations, visitors can converse with virtual characters through a touch screen to learn about the customs, religious beliefs, and social structures of the time. This interactive narrative not only provides rich historical

information, but also stimulates the audience's curiosity and exploratory desire.

3.3.2 Immersive virtual reality experience

Through virtual reality (VR) technology, museums can create immersive virtual reality experience scenes. By wearing VR helmets, the audience can enter a highly realistic virtual world, interact with exhibits, and even participate in historical events. For example, in an exhibition of war history, VR can allow viewers to experience the tense atmosphere on the battlefield, deepen their understanding and sympathy for historical events. The function of the Palace Museum's WeChat official account is to travel around the Forbidden City. Through VR panoramic technology, the Forbidden City is digitally displayed. Tourists can visit the Forbidden City through their mobile phones (Figure 1).

3.3.3 Augmented Reality Tour

Augmented reality (AR) technology has brought innovation to museum navigation systems. Viewers can use smartphones or AR glasses to view detailed information about exhibits, animated demonstrations of relevant historical events, and even expert instructional videos in real-time. This scenario based design makes the visiting process more vivid and interesting, while also providing a personalized learning experience [9].

3.2 Multi sensory experience

As an important place for cultural heritage and education, museums are gradually shifting their exhibition design from traditional static displays to immersive and interactive ones, aiming to deepen emotional resonance and cognitive understanding by triggering audiences' multi sensory experiences. The core of this design concept lies in comprehensively mobilizing the audience's visual, auditory, olfactory, tactile, and even gustatory systems, constructing a multidimensional perceptual environment, and thus achieving a richer and more profound cultural experience. Specifically, this process can be divided into the following four main aspects:

3.2.1 Visual experience

The interactive experience design of museum exhibitions is first and foremost a visual art, and museums attach great importance to pursuing the artistic effect of visual experience in interactive design. Among them, the visual elements of form and color are the focus of designers' attention [11]. As the first observation element for people entering space, the sensory experience obtained through vision is very important. By carefully arranging visual elements such as lighting, color, shape, and dynamic images, designers can create dynamic and layered visual landscapes, guide the audience's gaze, and stimulate their interest and curiosity in the exhibits. The design of visual experience needs to consider the audience's visual trajectory, ensure effective transmission of information, and create an atmosphere that is in line with the theme, enhancing the artistic and infectious power of the exhibition.

3.2.2 Auditory experience

In museum interactive display design, adding depth to visual information through sound, music, commentary, and other means helps visitors better understand and feel the exhibition content. High quality audio equipment and precise sound field layout are key to achieving a good auditory

experience. The selection of background music, simulation of environmental sound effects, and recording of professional commentary should be closely linked to the exhibition theme, aiming to create a sense of being in the environment and strengthen the emotional investment of the audience.

3.3.3 Olfactory experience

Smell is an emerging sensory interaction method in museum design. Some exhibits have their own taste, but in today's exhibition halls, the exhibits are stored in enclosed spaces, and people cannot personally experience their connotations. Smell has a special impact on emotional memory, such as ancient spices, natural flowers and plants, and the smell of coal smoke from the industrial era. It can activate the audience's memory and association, making them have a more intuitive feeling of specific historical periods or geographical regions. The design of olfactory experience should be cautious to avoid overly strong or discordant odors that interfere with the overall experience.

3.3.4 Tactile experience

Tactile experience refers to the way in which external stimuli such as vibration, compression, temperature, humidity, etc. are received through the body's skin to obtain corresponding emotional changes, which can directly affect a person's psychological activities and behavior. Nowadays, most museums post "Do Not Touch" next to their exhibits, and the demand for tactile experience will completely break the traditional display form of museums. Visitors can appreciate the exhibits in all aspects through the combination of touch screens and 3D modeling. Considering the most objective aspect of touch is the feeling of materials. At the same time, based on the concept of protecting cultural relics, the materials used in the exhibits can be created through modern techniques, providing visitors with a way to understand materials.

4. Conclusion

The application research of digital design in museum design reveals how technological progress profoundly changes the display mode, educational function, and audience experience of museums. The introduction of virtual reality (VR), augmented reality (AR), and interactive design has created unprecedented opportunities for museums. VR technology provides an immersive experience by reconstructing historical scenes and artworks, making the audience feel as if they have traveled through time and space, and have a direct conversation with the exhibits. AR technology enriches visitors' knowledge acquisition channels by overlaying virtual information on real exhibits, while enhancing interactivity and fun, making the learning process more vivid and interesting. Interactive design focuses on optimizing the navigation system, ensuring the readability and personalization of information, and providing customized visiting experiences through multimedia terminals and mobile applications to meet the needs of different audiences.

In summary, digital design not only breaks through the physical limitations of traditional museums, but also greatly broadens the boundaries of cultural education. It promotes audience participation, enhances the educational effectiveness of museums, and achieves digital sharing of cultural resources. However, with the rapid development of technology, museums are also facing challenges such as continuously updating technological facilities, protecting audience privacy, and balancing online and offline experiences. In the future, museums should actively explore new applications of digital design, while paying attention to humanistic care and technological ethics. With the power of technology, cultural heritage can be revitalized, connecting the past and the future, and inspiring cultural confidence and creativity in society.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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