"How Can Visual Arts Promote Social Integration?: A Study on Museum Visitors' Participatory Use of VR & AR

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Abstract. With the popularity of virtual reality technology, the interactive design has been widespread in the display process of immersion virtual museums. Based on the questionnaire analysis of museum visitors combined with in-depth interview of VR & AR technology users, this study analyzes the characteristics, functions and prospects of VR and AR technology in virtual museum display in China, explores the interactive design in the exhibition of immersive virtual museums with user experience and proposes a VR & AR-SI model based on Unity 3D and Unreal engine. The virtual interaction design represented by the application of VR & AR has changed the traditional display mode, broke the constraints of time and space, enhanced the enthusiasm of the visitors, and further enriched the museum's display form, which also pointed out that the interactive design realized through virtual technology has played a significant role in promoting social integration and would be the development direction of the future immersion virtual museum.

Keywords: VR & AR · virtual museum · social integration · VR & AR-SI model

1 Introduction

In recent years, people's demands for cultural consumption have been constantly increasing. The museum, as an important place for human cognition, culture and civilization, has received great public attention in terms of the way it displays exhibits. The traditional mode is manifested as the form that all exhibits are displayed in a static manner in the window with limited textual descriptions, which makes visitors feel bored and difficult to observe the detail of exhibits. With the rapid development of information technology, the interactive display mode of VR (Virtual Reality) and AR (Augmented Reality) has gained more popularity, and many scholars at home and abroad have explored the application of AR technology. For example, the earliest AR prototype system, which is a handheld application, can provide visitors with 3D graphic information of architecture and cultural relics [1], the virtual digital system of Old Summer Palace is developed based on augmented reality technology through perspective helmets and other display devices [2], and the augmented reality technology can also help develop a dinosaur museum [3].

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With the rapid development of society and the continuous improvement of people's living standards, virtual reality technology has become more and more important in all walks of life, and its value has been increasingly prominent. The fact that the Virtual Louvre Museum and the Virtual British Museum are popular all over the world has proved that the traditional museum display design cannot meet the current needs of the times, and the virtual museum construction based on VR technology is crucial to the promotion of museums. The virtual museum lies in the point view of the user experience, which displays the information of exhibits in a multi-sensory, multi-level and three-dimensional way to the audience, so that users seem to be in the virtual museum scene to get the immersive mood. At the same time, the application of virtual reality technology into the interactive design of virtual museum display is a brand-new breakthrough, the purpose of which is also to allow people to be in a virtual space for multi-dimensional and all-round review of the environment of the museum.

Although the VR and AR technology have been widely applied in the exhibition of the museum, its efficacy in improving the visiting experience is far from enough limited to the disconnection among the technology development, exploration of cultural connotation and the user perception. On this basis, this study employs the questionnaire method combined with in-depth interview method to analyze the strategies for improving the application of VR & AR technology in the museum that can be in accordance with the visitors' information-seeking, aesthetic and educational needs.

2 Literature Review

The concept of VR was first proposed by the founder of the American company VPL, Lanier, in the early 1980s, which refers to a high-tech simulation system generated by various computer technologies such as virtual simulation, display technology, sensing technology and artificial intelligence [4]. It's featured with the empowerment for the users to take the role of the master into a virtual space environment composed of computer graphics technology through a series of interactive operations with the help of VR equipment. In this virtual environment, the users can achieve a more comprehensive experience of the three-dimensional virtual space environment in order to be informed of the graphical information data. The British Computer Society defines augmented reality as "combining the digital world with the physical one and therefore augmenting the real-world experience" [5]. This technology has attracted the attention from both the commercial industry and academia due to the prevalence of head mounted devices (HMDs) and smart devices such as phones, tablets and handheld games consoles that have intrinsically woven into human's daily life [6].

The main difference between VR and AR is that AR integrates the virtual and real worlds, while VR offers complete immersion into a simulated environment and is entirely digitized. AR and VR are typically associated with younger populations, since these are sophisticated technologies, perceived as most suited for gaming platforms, and have characteristics such as being complex to set up and use. By 2021, the AR market size has exceeded US $133.78 billion and that of VR has reached $75 billion [7]. Augmented reality (AR) and virtual reality (VR) technologies have generated profound impacts in a wide range of areas, including gaming, navigation, medicine, education, and design

[8]. In this sense, many scholars realize that AR and VR technologies have the potential to promote social integration, since they have positive effects on the minority groups' physical well-being, psychological well-being and social well-being [9].

The fundamental purpose of museum display lies in the two-way feedback process, emphasizing the visual art information transmission and audience's comprehensive perception. The simple accumulation of words and pictures cannot fully impress the audience, and what the visitors really need is the information design with strong visual stimulation and spiritual shock. The spatial form of museum display is an important part of the formation of visual art, mainly composed of various visual elements involving furniture, exhibits, space, color, lighting, etc., to build a perfect visual display atmosphere. The use of imagination, creativity of the scene, and a strong visual language contribute to creating a display space of contextual beauty, presenting pursuit of higher cultural heritage and enhancing the excitement of the audience. The visual art that contemporary museums display has developed into a comprehensive embodiment of modern technological achievements and the integration of digital integration, sound, light, electricity, etc., which correspond with the update and expansion of the functional space. The adoption of coordinated space design is the key to constitute dynamic rhyme, smooth rhythm and other visual art effects in display design [10]. Museums as an augmented reality learning environment is a concept that has been explored for various means, from educational benefit to usability. Usability of augmented reality devices for museums and cultural heritage sites is an important area that also must be considered, as the effectiveness of the technology will be impeded if the visitor is unable to reliably control the system. The creation of a virtual museum guide, has been proved to make a difference within the context of using the Microsoft HoloLens as their hardware [11]. Augmented reality usage for museums stems beyond user enjoyment, there are many elements to the use of such a system with more factors to consider [12]. The use of the augmented reality was to provide interactive storytelling experiences that were related to the exhibits and included features such as videos, games, audio narration, imagery and digital reconstructions. The future of augmented, mixed and virtual reality research was discussed in a paper by Bekele et al., [13] in their survey of these technologies for usage in cultural heritage. On this basis, the museum can meet the visitors' various demands related to aesthetic satisfaction, information acquisition of history, culture and arts, as well as the extracurricular educational improvement.

3 Methodology

The data for this study is collected in one week in National Museum of China which has put the VR-AR hybrid display mode into use. This study selects 120 visitors as the research sample, who have once used VR & AR technology when visiting this museum. These 120 samples were distributed in six age periods respectively, 10–20 years, 21–30 years, 31–40 years, 41–50 years, 51–60 years and older than 60 years, thus 20 interviewees for each range. The questionnaire consists of two parts, the demographic information including gender, age, educational background, job, etc., and the main body of the questionnaire that contains the following questions:

Q1: What's the frequency of your visiting the museum?

Q2: What's the purpose of your visiting the museum?
Q3: Do you achieve the purpose through this visit to the museum?
Q4: Which way do you prefer when visiting the museum, written descriptions, tour guides, audio guides, interactive electronic devices represented by VR & AR technology or films?
Q5: Do you think the use of VR or AR technology has helped you achieve your purpose?
Q6: Do you think other ways of visiting have helped you achieve your purpose?

After collecting, processing and analyzing the questionnaire, seven representative samples have been invited to conduct the in-depth interview, the questions of which mainly concentrate on the function of VR & AR technology in meeting users' social demands and improving their social integration, involving the frequency of using VR & AR technology when visiting the museum, the reason why they prefer the VR & AR technology for visiting, the degree of use-satisfaction, the motivation to promote this technology for other museums, etc. This research aims at providing the broadest possible perspective, so the research sample selection focused on individuals from all walks of life to guarantee the variety of visiting purposes.

4 Findings

The museum exhibitions are usually designed for individual visits and equipped with elements supporting visitors in the interpretation process: written descriptions, tour guides, audio guides, interactive electronic devices represented by VR & AR technology, films, etc. However, the forms that different groups prefer takes on the prominent distinction (see Table 1).

Among the groups who prefer the use of interactive electronic devices represented by VR & AR technology, the group aged 10–30 years occupies the largest proportion, while the older group like 51–60 years old and more than 60 years old prefer tour guides and written descriptions to the VR & AR technology (see Table 1). It reveals that the penetration of VR & AR technology takes on the digital divide between the younger generation and older generation.

Different groups' views on VR & AR technology have great influence on their preference of using it. As for the period of 21–30 years, they don't think VR or AR technology is not useful, so they prefer the VR & AR technology to other forms (see Table 2). Moreover, different groups use the VR & AR technology to satisfy various needs, among which entertainment and educational improvement are the main purposes for the younger generation, while the entertainment, information-seeking and aesthetic satisfaction are the main motivation for the older group to use the VR & AR technology (see Table 2). Particularly, the groups aged 31–40 years old and more than 60 years old hold the most negative attitudes towards the application of VR & AR technology.

To investigate the reasons behind these distinctions, we invited 7 representative samples to conduct the in-depth interview.

Q1: What's the purpose of using VR & AR technology and how often?

Sample 1 (13 years old, a junior high school student): I am very curious of this brand-new creation, including the way how it displays the exhibitions and what's its difference from my eyes. To be frank, I will have a try every time I come to visit.

Table 1. Preference of Visiting Form

	10–20 years	21–30 years	31–40 years	41–50 years	51–60 years	More than 60 years
written descriptions	10%	15%	25%	25%	40%	20%
tour guides	0	5%	25%	20%	30%	40%
audio guides	15%	10%	5%	15%	5%	20%
interactive electronic devices represented by VR & AR technology	45%	40%	25%	10%	5%	5%
films	30%	30%	20%	30%	20%	15%
Total	100%	100%	100%	100%	100%	100%

Table 2. Views on VR & AR technology's satisfaction for personal needs

	10–20 years	21–30 years	31–40 years	41–50 years	51–60 years	More than 60 years
entertainment	30%	25%	15%	35%	40%	30%
Information-seeking	30%	40%	5%	20%	30%	10%
Educational improvement	20%	15%	5%	15%	0	10%
Aesthetic satisfaction	15%	20%	25%	15%	15%	20%
No use	5%	0	50%	15%	15%	30%
Total	100%	100%	100%	100%	100%	100%

Sample 2 (71 years old, a retired manager): Since I have worked in the Science & Technology industry for more than 40 years, I am sensitive to the innovative creation of information technology. Therefore, I may explore the improvement of this technology through each visit to the museum.

Sample 3 (37 years old, the worker): I accompany my son to visit the museum every week. Once I have tried the VR & AR technology, but I won't use it next time since I cannot sense the distinct advantage of this technology.

The interview also shows that the more they prefer to use the VR & AR technology, the more they want to promote the use of this technology in other museums.

Q2: If you have the opportunity to promote the application of VR & AR technology in museum display mode through participating in the initiative movement, will you take efforts to carry out it?

Sample 4 (19 years old, a college student): I will actively promote the use of this technology because it does bring a great many convenience for our visits. When I use this technology, I feel I get fully immersed in the historical background of that era.

Sample 5 (41 years old, a government servant): I think it's the relevant organizations that should assume the responsibility to promote the development and popularity of this technology and it's impossible to replace all the traditional forms of guide with VR & AR technology.

The degree of use--satisfaction also varies with the purpose of the visit. For the group with purpose of aesthetic needs, the degree of satisfaction after they use the VR & AR technology is lower than that of the group with educational and information-seeking demands.

Q3: What's the purpose of your visit to the museum and will you continue to use the VR & AR technology?

Sample 6 (24 years old, a graduate of visual arts major): I come to visit for seeking the design inspirations and I refuse to use this technology because it blurs many details of the exhibitions' design but put more emphasis on the design of the scene. That's not what I want.

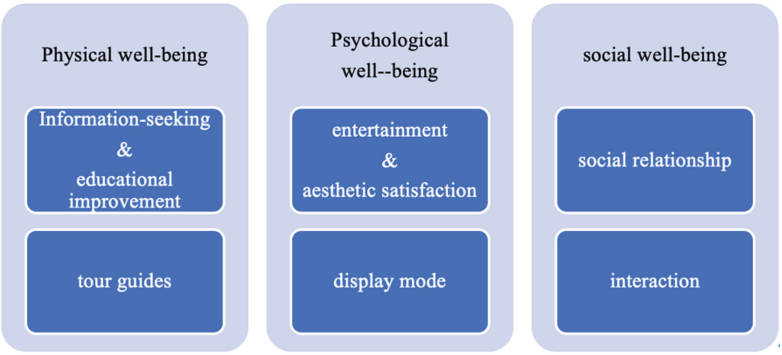
Sample 7 (39 years old, a professor of history major): I have intended to take photo as my lecture material but am attracted by the VR & AR technology by accident. I also want to add the introduction to this technology into my teaching content and eager to have a try next time.

In conclusion, each age period of samples contains a variety of needs, which have great influence on the preference, frequency and use-satisfaction of using VR & AR technology and the intention to promote its application. Compared to the professionals who possess higher aesthetic requirements, the group with educational and information-seeking needs are more satisfied with the application. The lack of use satisfaction also reveals that the development of VR & AR technology applied in museum display, guide and publicity is still immature in China. However, there is no denying that the application of VR & AR technology does enhance the social integration in terms of the family interaction, educational extension and entertainment for the elderly, free access to more cultural information for the needed, etc. To better enhance the social integration function of VR & AR technology, this research proposes a VR & AR-SI model that organically combines the application of VR & AR technology with three levels of social integration, and then this model will be tested with the use of Unity 3D and Unreal engine.

Compared to content-based 3D model, where retrieval starts with automatic calculation and extraction of 3D model features such as shape, spatial relationship, material color and texture to establish a multidimensional information index, this VR & AR-SI model is based on three levels of needs, which tries to use the visual characteristics of the 3D model to automatically establish the demand index (see Table 3). This need-based 3D model retrieval technology matches the similarity of visual features to operate the function requested by the user, which is closer to the way people use the tool by intuitive needs in real life. Referring to the Euclidean Distance Formula of 2D model [14]:

$$D(X, Y) = \sqrt{\sum_{t=1}^{n} (x - y)^2}$$

Table 3. VR & AR – SI model



the Euclidean distance of this VR & AR – SI model can be calculated by the formula:

$$D(X, Y) = \sqrt{\sum_{t=1}^{n} w * (x - y)^2}$$

The "w" signifies the index of need. Input the various demands of entertainment (n = 1), information-seeking (n = 2), educational improvement (n = 3) and aesthetic satisfaction (n = 4) into the Unity 3D and Unreal engine, and work out the dynamic programming and elastic-matching distance according to the following formula:

$D(X, Y) = g(x_n, y_n)$

$$g(x_n, y_n) = \min[\, g(x_n, y_{n-1}) + \Delta g(x_n, y_n) \\ g(x_{n-1}, y_{n-1}) + 2\Delta g(x_n, y_n) \\ g(x_{n-1}, y_n) + \Delta g(x_n, y_n) \,]$$

$$n = 1, 2, 3, 4 \ldots g(x_n, y_n) = \sqrt{|x_n - y_n|^2}$$

5 Conclusion

VR & AR products based on exhibition resources, experiential learning and practical learning are not the whole for museums, but the communication and education programs based on VR & AR technology has become the mainstream in the museums. The VR and AR technology can enhance the user's observation of the real world with virtual additional information, which can fully motivate the visitors' participation from their standpoint. However, in the concrete practice, some problems have emerged that the sense immersion is not strong enough in the process of museum visits, since visitors want to be in close contact with the model in the scene when they apprehend the history and culture contained in the exhibits and carefully examine each detail to supplement

the information that are not easily observed by the human eye when observing. Furthermore, the development of technology overlooks different needs of various users. The communication objectives of the exhibition are a system that runs through the whole process of the exhibition. In addition to the general communication objectives, parts, units, groups and points also have communication targets and are the specification of the general communication objectives of the exhibition, which is also the case for VR & AR products in science and technology museum exhibitions and educational activities.

In order to overcome these problems, VR technology-based exhibit display method is supposed to not only break the traditional static window display method and adopt a two-way interactive way to switch between virtual reality and augmented reality, greatly enhancing the participation and interactivity of the exhibition, thus overcoming problems in the communication and interaction of augmented reality technology and enabling people to obtain better immersive experience, but also be designed for the users' various needs involving aesthetic, informational and education level, to promote their social integration.

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