

# Study of Immersion in Augmented Reality Through Analysis of Immersion Elements in Museums

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**Abstract:** With the advent of the information age, augmented reality technology can enhance the sense of reality in the virtual world and immerse people in the real and virtual world. People have always been interested in virtual space or augmented reality technology, especially in the face of historical development trends. Museums have always been open to the public, they are not just a collection, but also an exhibition for the public. Through analyzing different museums, it is found that museums with augmented reality technology exhibitions are non-profit museums for the purpose of emotional experience. In order to find out the immersion factors of virtual reality in museums, on the basis of previous research, this paper divides immersion in augmented reality into story immersion, five-sense experience immersion, and spatial interaction immersion. Through the analysis of different museums, it is found that immersion through five-sense experience is the most commonly used method when all display media are included. This method provides educational content for museum visitors and projects virtual presentations through monitors and portable IT devices, thereby increasing visitors' viewing pleasure.

**Keywords:** Exhibition; Museums; Immersive experience; Augmented reality

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## 1. Study background and purpose

In recent years, due to the progressive development of information technology, people's lives have undergone fundamental changes. It has gone beyond simple communication and exchange between people. The development of technology has brought in new changes between people and space as well as space and environment. People can freely search for information any time anywhere since it is no longer limited by time and space. Therefore, augmented reality (AR) involves virtual information in the real world, enabling users to access their own unique and value-added information in real time. AR has emerged with the development of smart phones and technologies that use visualization to provide information. Virtual reality (VR) refers to a state in which a user is immersed in a virtual environment and provided with information. During this time, the user is unable to see the real environment. In VR, the real and virtual worlds are seamlessly connected, adding a sense of realness and immersion. Compared with the existing space, the space using AR can provide users with

more interesting and preferred content. This can trigger the possibility of spontaneous participation of visitors, and thus providing users with unique value-added information to meet the new exhibition experience.

On the other hand, a museum conveys information to tourists through the collection, preservation, and display of cultural relics instead of exhibition. It needs to increase the content that people find interesting through immersive education, experience, and learning. Therefore, this paper studies the AR technology used in museums, and the AR created through a higher sense of immersion. By analyzing its application, we hope to provide basic information for the efficient use of AR technology in the future.

## 2. Research method and scope

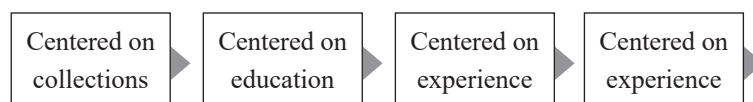
To study museums and AR through theoretical analysis of existing literature research and papers, the elements of museum immersion are obtained, and the concept and characteristics of AR are discussed. Additionally, through case analysis of domestic and abroad museums, this paper aims to understand the elements of museum immersion and the application of augmented reality. In the selection of museums for analysis, all non-profit museums were chosen, focusing on publicity and education.

## 3. Museum immersion and augmented reality

### 3.1. Museum immersion

#### 3.1.1. Changes in museums' focal point

In recent years, museums have been influenced by new museology that emerged from the late 1960s. New museology emphasizes that museums are educational tools for social development, and the center of museums is “people” instead of “things.” Museums do not only serve the purpose of collecting, but are centered on interacting with visitors and providing them with an immersive experience. As shown in **Figure 1**, museums' focal point has been changing with time<sup>[1]</sup>. In order to protect cultural relics, traditional museums usually collect them in showcases for display. With the introduction of AR technology, the damage to cultural relics caused by the transport of cultural relics can be reduced. Digital technology can be used to fully restore scenes and cultural relics, and achieve the combination of virtual and reality, thereby allowing visitors to be on the scene experiencing “up close” viewing of cultural relics. In addition, online exhibitions can also enhance the viewing experience. Visitors can check the corresponding information of museums, scenes, and cultural relics at any time, and fully understand the historical origin and cultural connotation. The multi-sensory interaction enhances the user's experience, and reduces problems such as poor accuracy of staff explanations and incomplete understanding of tourist information.

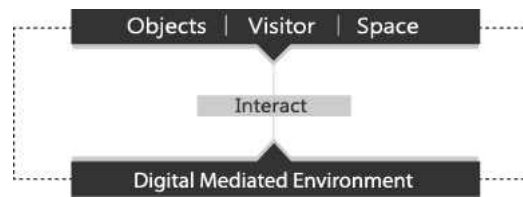


**Figure 1.** Changes in museums' focal point with time

The museum's exhibition method also needs to be changed. It should not be based only on one-way display of exhibits, but it should allow exhibits, visitors, and space to interact with each other, for visitors to have a more realistic experience.

### 3.1.2. Elements of museum immersion

The interactive elements of the exhibition halls are summarized in **Figure 2**. The interactive components of digital media feature display are divided into three, namely objects, visitor, and space, which interact with digital media environment <sup>[2]</sup>.



**Figure 2.** Interactive components of digital media feature display

Through this mode change, the experience in the exhibition halls not only affects the externally revealed morphological elements in the space, but also enhances and utilizes the interactive relationship between space, visitors, and exhibits, making visitors more immersed in the elements of exhibits <sup>[3]</sup>. Therefore, this article studies the papers of Kim <sup>[3]</sup>, Yoon <sup>[4]</sup>, and Song <sup>[5]</sup> on the communication between space, visitors, and exhibits, and draw improvements from communication elements that increase visitors' immersion in the museum. **Table 1** shows the elements of immersion in museums obtained from the research papers <sup>[2]</sup>.

**Table 1.** Elements of museum immersion derived from prior research

Structure-integration (Operating system approach)	Boundary-interactivity (Experiential deduction)	Environment-complexity (Deductive space environment)
Create empathy through storytelling	Communicate through sensibility	Enhance the visual means
Spatial structure (Circulation and building structure arranged by theme)	Content information, explanatory material, and experience elements	Special elements (According to brightness, light rays, space color, and other deduction space)
↓	↓	↓
Immersion through storylines	Immersion with five senses	Immersion through spatial interpretation
Provide an immersive experience through exhibits and routes in the storylines	Stimulate the five senses and guide the audience to interact	Use the space as a whole to show the interior space and exhibits

### 3.2. Augmented reality (AR)

Concepts and properties of augmented reality

AR seamlessly combines the real and virtual worlds, as a dynamic learning tool for users. It provides a user interface that allows freehand touch and body gesture recognition. The technology that provides objects and information allows users to see enhanced virtual content in the designed environment, providing a better sense of realness and immersion <sup>[6]</sup>. This explains the relationship between VR and AR, by which it interacts with the real world <sup>[7]</sup>.

According to the classification of display media, AR can be divided into four types <sup>[8]</sup>. **Table 2** shows the types of AR classified by display media based on their characteristics <sup>[2]</sup>.

**Table 2.** AR classified by display media

Display media	AR	Interactive features
Monitor	Monitor-based display	Real world and virtual information provide overlapping images and information through fixed monitors.
HMD	HMD-based display	Optoelectronics-providing information through glasses Video-provides video information through the camera
Projector	Space display	Provide images and information by outputting images through a projector, making full use of the space
Handheld	Handheld equipment display	Provide information through portable and mobile IT equipment and marking technology

## 4. Case summary

The case studies of this article include non-profit museums with educational purposes in domestic and foreign museums that enhances the use of technology. The museums are displayed in **Table 3**.

**Table 3.** Museums selected for case analysis

No	Name	Location
1	Netherlands Open-Air Museum	Netherlands
2	China Giant Panda National Park - Wawushan Panda Museum	China
3	Dubai Museum of the Future	Dubai
4	National Museum of Korea	Korea

### 4.1. Case analysis

#### 4.1.1. Netherlands Open-Air Museum

Netherlands Open Air Museum focuses on the interactive experience of visitors and achieved perfect combination of visitors and historical empathy. By studying the related culture, the exhibition design is imagined as a multimedia collection, combining physical interaction and audio-visual media with unique collection demos. The floors and walls are designed with graphic patterns that are all related to the geographical changes of the Dutch country. The seats are also designed as an abstract ground floor. There is also an interactive wall with a width of 18 meters, which displays all fifty windows in chronological order. Each window can be used for digital treasure hunting activities. Visitors of all ages can play games on the interactive tables. The empathetic exhibition method enables visitors to have an extremely rich immersive experience.

#### 4.1.2. China Giant Panda National Park - Wawushan Panda Museum

This museum uses multimedia interactive devices such as naked-eye 3D columns, fog screen projections, LED infrared combined with sensing systems, etc., to restore the ecological scene of Wawu Mountain. The museum exhibits the streams and mountain scenes as if being in the real mountain, the dynamic scenes are highly integrated with the flora and fauna landscaping, thus reflecting the characteristics of ecological diversity of Wawu Mountain. There are also several interactive exhibition items interspersed in it. Visitor interaction adds a lot of enjoyment and participation.

### **4.1.3. Dubai Museum of the Future**

To display an immersive show about human life and the future of individual life forms in the Earth and space, the Land of Hope uses digital interactive technology to simulate the scene and experience of space travel. The holographic projection is set up to make visitors feel like they are in the Milky Way. There is also a simulated space station where visitors can observe the work in the space station and understand the missions of the astronauts. In the exhibition area of the Digital Research Institute, it is a digital Amazon jungle. In the ecosystem scene, visitors can observe the tropical rainforest, the survival and growth of hundreds of species, and their effects on the environment. At the same time, there is also a DNA library containing thousands of species. In the Waha Oasis display area, there are various meditation and immersive places, such as the room where waves and light patterns sway, and the room where Xisha flows slowly around visitors. The experience is like being in a paradise that reawakens the senses, and greatly relaxes the mind and spirit. In the Today Tomorrow exhibit, there are great inventions made by leading creators from all over the world, with the latest technologies to be added soon.

### **4.1.4. National Museum of Korea**

In the holographic animation exhibition hall, the National Central Museum digitizes the most common text information in the museum to combine three-dimensional (3D) animation and projection, presenting a 3D projection effect with a great sense of future experience. For example, the fragrance of petals can be smelled, allowing visitors to experience the feeling of being in a garden. The two-dimensional information in words is transformed into 3D display in an instant, allowing visitors to be completely immersed in it. In the Material Cultural Heritage Museum, through the application of advanced technology such as ultra-high-definition multi-sensor fusion, visitors can participate in the interaction of exhibits. For example, they can ignite the lights on the display screen with their fingers. The faster the lights on the screen are lit, the faster the rickshaw on the screen will run. In the VR experience area, 3D cameras are used to collect offline physical scene data for creating VR videos, so that every visitor can be integrated and immersed into the scene by wearing 3D glasses. The museum makes full use of multimedia digital technology effectively. The space in 3D is first scanned, then the rough model is restored through cloud artificial intelligence (AI). Subsequently, the panorama is merged, and the graphics, sound, light, electricity, and other forms of expression are combined. Using digital projection with light and shadow interweaving audio-visual technology, the history of the pagoda is displayed. Visitors can use AI and VR technologies to understand the historical context and changes from a panoramic perspective. Visitors can also interact with these immersive interactive devices when learning, which makes learning more interesting.

In the traditional museum display, visitors receive information through pictures, cultural relics display, and exhibition videos. With digitization of the museum, the exhibition content has been inseparable from multimedia and VR technology. This includes scene restoration, 3D animation, AI sensing, visual images, virtual technology interaction, etc., thereby providing visitors with exhibitions that can be seen, heard, smelled, and touched.

## **4.2. Analysis summary**

From the results of the previous case analysis, the most immersive element in the museum is based on the experience of the five senses, which is very important in all fields. The second element is immersion through the series of storylines and space performances.

Museums are undergoing a digital art revolution. Visual technology is used to enrich visitor experience and increase museum revisit rates. Therefore, it is a new trend for museums to vigorously develop digital experience

technology. Digital experience art is any exhibit that can be created through imaging technology and turned into a digital artwork, such as immersive digital image, splicing display, VR, and other technical methods for presentation. With the help of these visual technologies and equipment, the traditional exhibits can be innovated to make its performance richer and more appealing, this kind of technological change has important value for visitors' experience<sup>[2]</sup>. The museum can easily switch between new exhibitions. Through visual technology, it can flexibly change virtual exhibits and environments. Within a limited time, it can bring visitors infinite freshness and novel digital artworks. Based on young people's thinking and hobbies, the layout of the exhibition hall can be reshaped in the future, to further attract the younger generation. Visual technology can also create a new experience of art and entertainment, allowing interesting interactions between exhibits and tourists, thereby providing a unique immersive experience. Digital art also can break the limitation of space, allowing visitors from all over the world to enjoy the same exhibition theme at the same time. The global themed joint exhibition is becoming more and more popular. The application of visual technology and the innovation of digital art are undoubtedly new trends in the development of museums.

## 5. Conclusion

In order to grasp the AR characteristics of museum immersion for perceptual, educational, experiential purpose, various domestic and foreign museums are analyzed. Through the case analysis, it is concluded that the immersion elements of museums are immersion through storyline, immersion through five senses experience, and immersion through space interpretation. The technology of AR is divided into monitor, HMD, projector, handheld, etc., according to the type of display media. All the five senses are used to fully immerse into the elements for better experience. Designing storyline by using smartphones can provide content for immersive experience. Plus, there is an immersive way of interpreting through space. The characteristics of the AR display media mainly include displays, mobile IT devices, etc., to organize storylines through media, or to improve immersion by providing visitors five-sense experiences. On the contrary, the use of projector that improves immersion by showing the space as a whole is relatively rare. Therefore, based on these results, there is an infrequent use of spatial elements in museums in order to provide more immersion. It is necessary to use the elements of space performance when using AR to increase future investment in museums. Based on this study, the use of space performance will be studied in future research.

## Disclosure statement

The author declares no conflicts of interest.

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