

RESEARCH ON AUGMENTED REALITY DISPLAY TECHNOLOGY OF CULTURAL RELICS – TAKE THE BELL AND DRUM TOWER ON THE CENTRAL AXIS OF BEIJING, CHINA AS AN EXAMPLE

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ABSTRACT:

The current global digital technology is in the era of accelerated iteration, with 5G, AR, VR and other technologies of scientific and technological research, new application scenarios of heritage buildings have also achieved innovative breakthroughs. This paper comprehensively reviews the development status of augmented reality display technology, and takes Beijing Drum Tower, an important conservation display technology innovation pilot of Beijing's central axis heritage application, as a theoretical and practical research blueprint. With full respect for the conservation requirements of the heritage buildings, the most appropriate and lightest augmented reality display means are used to fully express and explain the architectural heritage connotation and strengthen the public interactive experience. Through case analysis, a systematic technical process of augmented reality display design for heritage buildings is summarized and formed, and a practical guide for the technical adaptation of heritage buildings is established. Finally, facing the trend of innovative exploration of augmented reality technology and devices, the future development of AR technology in the field of cultural and museums was foreseen.

INTRODUCTION

Heritage buildings are important carriers of the heritage of human civilization, and they have been passed on from generation to generation and lived on in the long history.. After passing through the vicissitudes, heritage buildings are attached with all kinds of historical and cultural information that can serve as a witness to human life. The display of cultural relics and buildings and the interpretation of their value can hardly meet the needs of cultural heritage display and education, as well as the experience needs of the general public through traditional physical exhibitions, textual descriptions and guided tours.

The real-time interactivity of augmented reality technology, and information integration in real world and virtual world , add more possibilities to the digital display of cultural heritage, inspire a strong sense of scene and participation of the experienter, and give cultural heritage a new vitality through virtual presentation, dynamic enhancement and other display and dissemination means, Augmented reality technology becomes more natural because of its connection with the real world and the picture association is not cut off, and the way of interaction becomes more natural, providing an innovative form of online and offline integration of experience.

Meanwhile, mobile devices, such as smartphones, tablets, and innovative products such as professional AR glasses, are driving the combination of augmented reality and mobile technology, bringing better prospects for augmented reality applications, especially in the field of heritage sites and cultural tourism. The development of augmented reality technology has provided richer application methods and more advanced technical support for the digital display of cultural heritage.

From the perspective of culture and heritage, AR technology is used to "revive" the disappeared cultural heritage in digital form. Through the construction of visual and contextual 3D animations, the ancient architectural scenes and key live events are virtually recreated. AR technology is used to superimpose this digital content on the real cultural heritage environment,

enabling visitors to experience the historical context behind the site. AR technology is used to visually recreate the historical scenes at the site in real time, while maintaining the site's appearance intact.

Within cultural sites, augmented reality is an influential digital interactive tool. AR technology is used to virtually reconstruct the missing parts of the site and superimpose the content information that is difficult for people to perceive in real time, so that the "invisible and untouchable" historical and cultural information is transformed into a contextualized and visualized digital cultural form, thus enabling effective interpretation and dissemination of culture while promoting effective conservation. There are more than 300,000 sites in China, each carrying a different history and culture, with different states, scales, survival, site conditions, and display environments. On the other hand, there is a difference in the public's desire to visit the site. This shows that combining AR technology with cultural heritage exhibition display will become an important development direction in the field of cultural heritage.

1. AUGMENTED REALITY TECHNOLOGY OVERVIEW

1.1 Common forms of augmented reality technology

Augmented reality (AR) is a technology that cleverly blends virtual information with the real world to create a virtual reality interactive experience. It is defined as "An environment that uses additional information generated by modern high-tech means with computers at its core to enhance the real world as perceived by the user. The generated information is superimposed on the real scene as a fusion of visual, auditory, taste, smell, touch and other physiological senses." According to different application requirements, augmented reality experience can be realized in various ways and with the help of different hardware devices, the common ways are shown in Table 1. The exhibit adopts the form of mobile augmented reality application, which is suitable for indoor and outdoor environments and supports the layout design and multi-point

experience. Achieve a variety of technical effects and support a variety of display forms. With the spreadability, can use the Internet to achieve wide dissemination. The experience is realized by downloading the client for free, which greatly reduces operation and management costs.

Type	Common Hardware	Features
Fixed virtual image display device	Holographic device/OLED	Can achieve stunning visual effects; mostly fixed exhibits, poor flexibility, high implementation and operation costs.
Professional headgear	AR glasses/AR headset	Interesting, can achieve a variety of technical effects; applicable environment is limited (indoor only), operation and management costs are low.
Mobile display side	Mobile phone/pad/guide	Flexible, suitable for all kinds of environments, can achieve a variety of technical effects, with the dissemination, low operation and management costs.

Table 1. Augmented reality device analysis.

Mobile augmented reality technologies can be broadly classified into two types of technologies based on the differences in triggering methods. First, the AR virtual interaction experience is reached through feature point recognition. Suitable for two-dimensional pictures, three-dimensional models and small scenes recognition, for large scenes difficult to set feature points, easy to replace and update the content, but vulnerable to light, angle, obscuration and other factors affect the recognition accuracy. The second is to reach AR virtual interactive experience through empty point positioning. Accurate positioning, up to centimeter level, not affected by light, angle, obstructions and other factors, suitable for large scenes and outdoor scenes, accurate display of the virtual image in the reality of the location of the relationship, providing a strong sense of experience.

1.2 AR Application Development

The augmented reality-based tour and display system takes the experience user as the service object and the electronic device as the medium to provide the experience user's visual and auditory senses with augmented reality experience combining digital content and reality to improve the visual display effect, strengthen the content expression and enhance the offline experience. The system contains three parts: the basic hardware layer, the data layer, and the application layer.

(1) Foundation layer

The basic layer mainly contains the development environment that supports the operation of the system software, including database server, application server, wired network, etc.

(2) Data layer

The database of the data layer is mainly used to store the system graphics database and the attribute database. This includes all types of metadata, spatial/non-spatial data, text data, and spatial databases of information dynamic management systems, etc. that are managed and driven by database management systems

and spatial database engines. The data layer includes the platform-related databases and the basic component libraries for accessing and managing these data.

(3) Application layer

The application layer mainly faces the end users, i.e. the functional modules provided to the end users. The overall logical structure adopts a layered system, with each layer relatively independent of the other, and each layer interdependent from bottom to top, from data, basic functions, to applications. Each function and business application in the layer is designed and developed in a component manner to minimize the coupling of functions within the layer.

1.3 Application principles of AR technology in heritage buildings

The principle of AR technology application in the field of cultural heritage display is to serve technology in display and integrate technology into content, rather than highlighting technology and not caring about the amount of technical content, but to achieve "just right" and practically solve practical problems around user experience, so the application level should still follow the basic principles of content design. The basic requirements are as follows.

(1) Orientation principle: reflect and reveal the abilities, methods and achievements of human civilization at all stages of cognition, and conduct correct historical views and values.

(2) Scientific principles: reflect the advanced and stable knowledge system in this field, adhere to scientificity and objectivity, take scientific research results as the academic support of the exhibition, accurately reveal the connotation of exhibits, respect historical facts, and eliminate subjective fabrication.

(3) Communication principles: adapt to the cognitive characteristics of the public and deliver information that is easy to understand and accept.

(4) The principle of innovation: in line with the requirements of society and the stage of development of the museum business, advocating the originality and diversity of the exhibition.

(5) Aesthetic principles: focus on language, story, exhibit combination and other artistry to meet the aesthetic needs of the audience.

2. BEIJING CENTRAL AXIS BELL AND DRUM TOWER CASE STUDY

2.1 Project Overview

Beijing Bell and Drum Tower, as the northern endpoint of Beijing's central axis, is an important heritage site in Beijing. In 1996, the Bell and Drum Tower was announced by the State Council as the fourth batch of national key cultural relics protection units, and in 2022 the Drum Tower completed the digital display project, becoming a representative result of the digital display of cultural heritage. A large number of digital technologies were applied in the Beijing Bell and Drum Tower digital display project, including augmented reality technology, virtual reality technology, and immersive light and shadow technology. This project is based on augmented reality technology, using cell phones as the display medium to complete the AR exhibit design, providing online and offline integration of virtual reality interactive experience, which not only makes the overall display and experience level richer, but also gives full play to the advantages of AR technology, breaking space limitations and extending the exhibition content.

2.2 Design Ideas

For immovable cultural relics to carry out "not to damage the structure of the building, not to change the overall style of the building, not to cause pollution of the building, to preserve the original architectural features," the protection of display exhibition principles, on the basis of adhering to the priority of protection, respect for the original spatial characteristics and functional characteristics of the building, the cultural value of the Bell and Drum Tower to make full excavation and display interpretation.

With the help of technology, it further innovates ways to meet the current digital display by focusing on the historical evolution of the Drum Tower, the value link of the central axis, bell and drum culture, non-foreign heritage culture, and digital display. Through the addition of digital content to improve the interactivity and narrative of the exhibition, to release the vitality of the Gulou conservation display and enhance the effect of the exhibition display of Gulou heritage buildings.

Break the limitations of the existing space and dig deeper into the values of Gulou. Using the display method of viewing, experiencing and interacting, integrating knowledge, technology and interaction, through the vivid interpretation of culture, history and technology, inheriting in content, innovating in means, using the combination of reality and reality, deeply explaining the historical and cultural values of the central axis, making it the first demonstration point of heritage exhibition display on the central axis, and becoming a model case of telling China's story to the world.

2.3 Project Implementation

2.3.1 Needs and Objectives

In terms of exhibition space, the first floor of the Beijing Drum Tower building structure consists of nine coupon holes. The building area is about more than 1,400 square meters (excluding the area of the horse path), while the actual exhibition area available is less than 600 square meters. The three coupon holes in the center in the shape of a "cross intersection" are used as immersion theaters and are not suitable for exhibition in order to avoid the impact on the projection light path, thus the exhibition space is extremely limited.

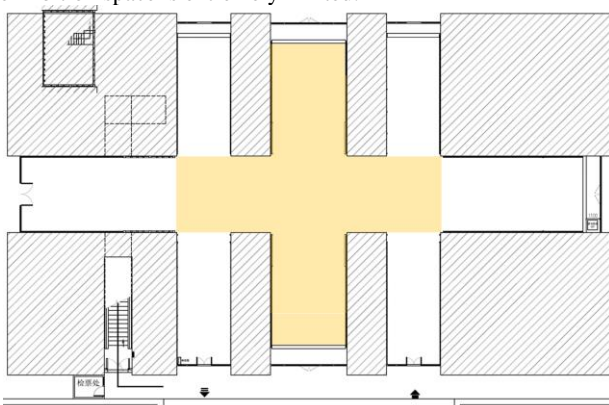


Figure 1. Plan of the first floor of Beijing Drum Tower .

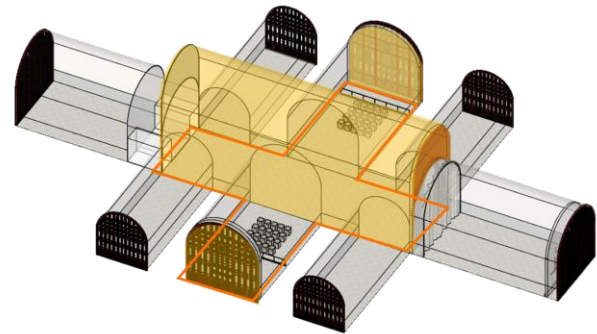


Figure 2. Stereogram of the first floor of Beijing Drum Tower.

From the content of the exhibition, the digital display of the Drum Tower not only covers the historical value and cultural influence of the Bell and Drum Tower itself, but also extends from the function to the development of the ancient Chinese timing and chime culture system, and from the geographical location to the unique urban regulations of Beijing's central axis, making the exhibition extremely rich in content.

Based on the above analysis, augmented reality exhibits urgently need to solve the following problems: ① infinite content extension within the limited space of reality; ② strengthen the interaction between visitors and display content, and enrich the form of experience.

2.3.2 Overall Planning

(1) Picture and text interpretation of the exhibition board is enhanced

Constrained by space limitations and the preservation of cultural relics and ancient buildings, the exhibition hall provides limited drawings and text, insufficient interpretation, the use of AR technology combined with the exhibition board graphics, virtual content provided by augmented reality to supplement the explanation, strengthen the interpretation while strengthening the interaction and enriching the experience.

(2) Virtual exhibition of heritage buildings

Based on the digital reconstruction of heritage buildings, virtual exhibition space is constructed to form a virtual exhibition of heritage buildings. Configure digital content in the virtual space, connect the virtual space with the real space through AR technology, and realize the presentation and dissemination of digital content by means of precise positioning trigger and feature point recognition trigger, which can break through spatial restrictions and realize unlimited extension of digital content.

(3) Linear enhancement, stringing dots into lines

Beijing Bell and Drum Tower, as the northern section of the central axis, is of great significance to the central axis of Beijing, but it is not enough to display the contents of the central axis only in the Drum Tower. Through AR technology to form a guiding effect, starting from the Bell and Drum Tower as the origin, mapping southward to each heritage point on the central axis, eventually guiding visitors to go out and drive the display of the whole Beijing central axis by stringing the line with points, while also providing a convenient condition and reference model for the display of other heritage points on the axis.

2.3.3 AR display system development

The AR application in this project integrates online and offline experiences to realize unlimited online content extension and enhance the interpretation level within the limited offline physical space, and its main feature is to realize online virtual roaming, offline mobile tour and in-depth interpretation at the

same time. Through the cell phone APP positioning recognition and feature point scanning, to achieve a dynamic augmented reality experience, so that cultural relics "live". Based on the research and digital reconstruction of cultural relics and buildings, AR display provides AR augmented reality interaction, virtual viewing, video explanation, voice explanation and other display methods. The AR technology adds interactive experience to the exhibition panels and walls, presenting virtual exhibition content and enhancing the richness of the experience. The exhibit hall adds AR virtual digital content and knowledge points to enhance content richness. The key version of the text comes with audio explanation to enhance interpretation. Visitors can independently find AR display points according to the AR exhibit logo, and interact with the exhibits through virtual reality overlay to enhance the interest of the tour.

AR exhibits are irregularly distributed in the exhibition hall to enhance the fun of exploration, and the length of interactive experience at each AR experience point is no more than 1 minute to avoid congestion caused by the crowd stopping for a long time. Visitors download the app on their own, find experience spots and use the scanning function to get an augmented reality experience. APP development includes the functions of augmented reality display, recording and sharing, which makes it easy for visitors to "take away the experience" and achieve wide dissemination. The system is equipped with a management backend that enables remote content management (add, modify, delete), effectively reducing management costs.

2.4 User Experience

The Beijing Drum Tower Digital Immersion Exhibition is open to the public in the form of self-guided viewing, with "Digital AR Viewing Tips" set up at the entrance of the proscenium, prompting visitors to scan the QR code or search for "RESeeAR" from mobile app stores to download the APP and experience the content of the digital space during the exhibition. In the process of viewing the exhibition, visitors can independently search for AR display points with special signs to experience the content of digital space.



Figure 3. Tips on the display board of the prologue hall of the Drum Tower in Beijing.

(1) Ancient bell casting

Take the "Ancient Bell Casting" AR experience site as an example, the display board contains a diagram of the ancient Chinese method of casting bells in the "Tiangong Kaiwu" (an ancient book), as well as a record of the ancient method of casting bells. Since the pictures and texts are from ancient

books, they are inevitably obscure to the average viewer, and it is difficult for visitors to understand their content without an interpreter.

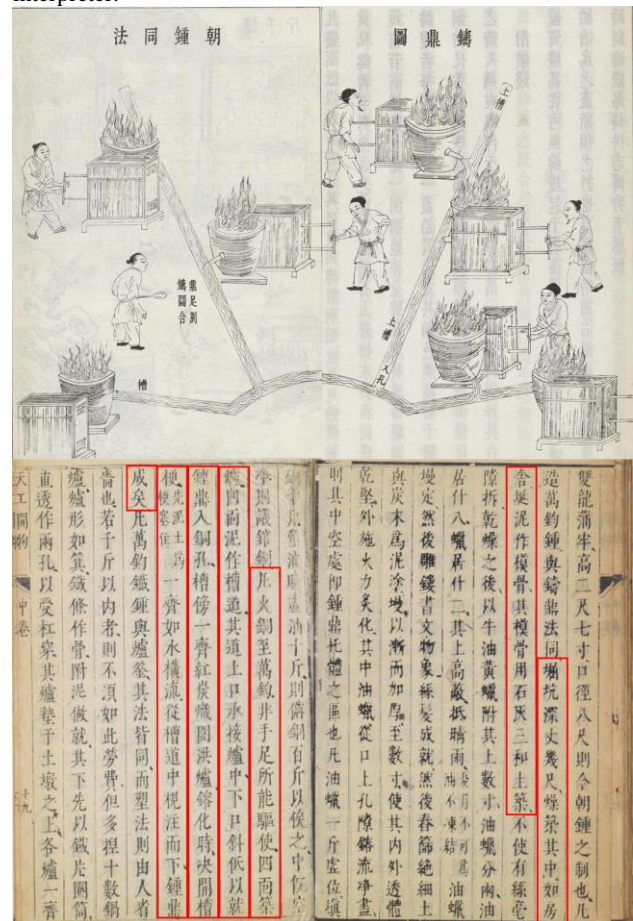


Figure 4. Picture-text records in "Tiangong Kaiwu".

The designers have enhanced the interpretation of this exhibit using AR technology, scanning the ancient method of casting bell schematics through an app to obtain an augmented reality experience, making the scanned schematics active. The original black and white ancient paintings are gradually colored, and the characters, tools, and flames in the paintings gradually have movements, showing animation effects, along with audio explanations, which explain the core meaning of the ancient texts and combine with animation to give the viewers a more intuitive, easy to understand and fun viewing experience. After the experience, visitors can save the augmented reality experience through the app and share it with friends and family.



Figure 5. The effect of "ancient bell casting" experience.

Thus, the AR application in the exhibition of the Drum Tower is combined with the display content in the real space, making full use of augmented reality technology to innovate the display method, explore the rich connotation, enhance the interactivity and experience, and let the cultural heritage "come alive and pass on". It embodies the concept of scientific protection, rational utilization and sustainable development, and meets the standards of world cultural heritage protection and management.

(2) Beijing Central Axis Wanderings

The design of the luminous art installation of the central axis in the end hall has a high aesthetic and ornamental value, while showing the overall scale of the Beijing central axis as well as the architectural style and location relationship of the heritage sites. However, it is limited to the display of physical exhibits and is still insufficient for the interpretation of the value of the Beijing Central Axis.

The designers here use the virtual layout of heritage buildings to present a virtual roaming experience through the central axis based on the spatial location of the central axis luminous art installation, and visitors can learn more about the value and connotation of Beijing's central axis through audio explanatory words during the virtual roaming experience.

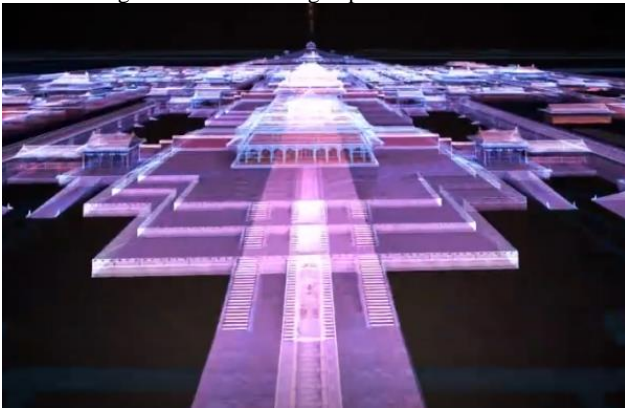


Figure 6. Beijing central axis roaming experience effect.

(3) Debris collection

The influence of the above-mentioned experience design on visitors' behavior is still limited to local experience. In the tail hall of the Drum Tower, although it has risen from the display of the heritage points of the Bell and Drum Tower to the overall display and interpretation of the value of Beijing's central axis, it has not yet given full play to the role of "stringing dots into lines".

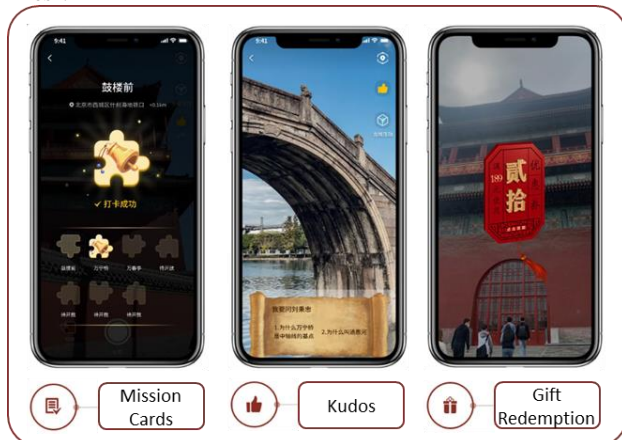


Figure 7. Fragment collection experience effect.

Based on the planning idea of " stringing dots into lines ", the designers finally designed the "fragment collection" experience

function in the AR exhibit, forming "task cards" for the overall touring experience of the Bell and Drum Tower, so that visitors can complete the first task card collection in the central axis. At the same time, different "mission cards" are set up at other heritage sites along the central axis, and visitors can redeem different virtual gifts for completing different tasks, thus transforming the tail hall of the Drum Tower into the starting point of the Beijing central axis and guiding visitors to other heritage sites.

3. SUMMARY AND OUTLOOK

3.1 AR technology has advantages in the field of cultural and museum applications

(1) Connecting the virtual world with the real world

With the development of digital information technology, the field of cultural and museums is also gradually transforming into the digital direction, and digital IP and digital collections are developing rapidly. AR technology can link the virtual world with the real world and integrate digital content with the physical display of cultural relics, which not only opens up a broader application scenario for digital content, but also enriches the content and interactive experience form of offline display.

(2) Mild intervention for cultural heritage ontology

Cultural heritage itself has a high value, the use of AR technology can not only achieve the strengthening of the display on the basis of the body of cultural relics, so that the static cultural relics "move", and in this way to display the body of cultural relics basically does not produce any adverse effects, to achieve mild intervention, which is conducive to the preservation of cultural relics.

(3) Extended interpretation content

The traditional offline fixed display of cultural heritage is constrained by space. AR technology can break the real space barrier through virtual overlay, which can present the interpretive content in virtual form and break through the limit of richness of content interpretation, and also provide convenience for the iterative update of content.

(4) The form of experience is interesting

Traditional cultural heritage is mainly displayed in the form of watching and explaining, and there is a lack of interaction between the audience and cultural relics, and the acquisition of cultural content and knowledge is passively accepted. Based on AR technology, various forms of interactive experiences can be developed to provide an environment that enables viewers to give full play to their initiative and creativity, changing them from objective spectators to active participants, thus mobilizing their initiative, hobbies and interests and making them more receptive to cultural content and knowledge.

3.2 Systematic technical process of augmented reality display design for heritage buildings

According to the above real application case analysis, the preliminary construction of a systematic technical process of augmented reality display design for heritage buildings can be divided into three stages: demand and target stage, overall planning stage, and AR display system development stage. The overall technical framework is shown in Figure 8.

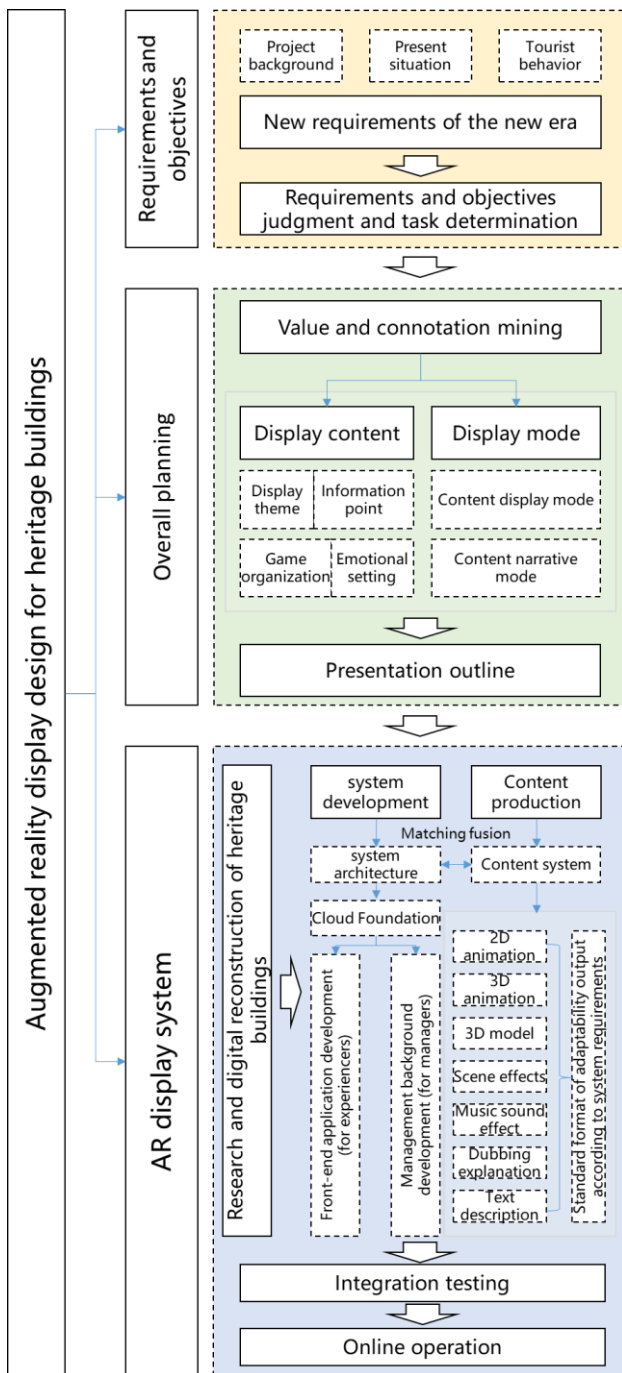


Figure 8. Systematic technical process of augmented reality display design for heritage buildings.

(1) Requirements and objectives stage

First of all, it is necessary to fully interpret the display project and clearly analyze the demand and target. The factors that determine the needs and objectives include project background, current situation, visitor behavior, etc. At the same time, the new needs of the new era should be taken into account, including policy guidelines, social development direction, technological innovation, public hotspots, etc. Under the guidance of the project needs and objectives, the work tasks are further defined.

(2) Overall planning stage

The application of AR technology to the display of cultural relics and buildings should adhere to the principle that technology serves the content, and the core of cultural heritage

display lies in cultural value and cultural connotation. Therefore, the primary task at this stage is to fully explore the cultural values and connotations, so as to guide the design of display content and display methods, and finally form a display outline.

(3) AR display system development stage

AR display system development can be roughly divided into three parts, heritage building research and digital reconstruction, system development and content production. The research and digital reconstruction of heritage buildings provide the basis for the virtual exhibition of the AR display system. The core system architecture design, content system design, and the final formation of the interactive experience are all completed around the display outline. The system architecture and content system match and integrate with each other, and the content system is designed according to the interactive functions formed by the system architecture, and the standard format is output according to the system requirements adaptability.

3.3 The future development of AR technology in the field of cultural and museums

With the development of the new era, the public's demand for high-quality cultural experience is growing, and the demand for cultural and museum displays is increasingly pursuing the content and form of technology, fun, creativity, the traditional display of cultural relics, text explanation, artificial guide can not meet the needs of people watching the exhibition. With the increasing maturity of digital technology, various forms of digital creativity are emerging in the field of cultural and museums, and the multiple advantages brought by augmented reality technology make it inevitable that it will become an important part of future cultural and museum displays.

The application of AR technology in the field of cultural and museums has more room for development, from heritage buildings and museums to heritage sites, from indoor to outdoor, there will be a greater demand for augmented reality technology applications for future heritage site displays.

The application of mobile devices combined with augmented reality technology at the site will require more demand for spatial positioning combined with site scene feature point recognition to trigger augmented reality interaction, for which there will be higher technical requirements. First of all, from the perspective of data volume, the scope of the site is large, generally need to build a three-dimensional spatial model of the site, used to record the real physical space information, designed for the display needs of the many heritage sites set by the augmented reality interactive content, will bring a higher amount of data requirements, for data storage, call a higher technical requirements. From the perspective of algorithm difficulty, outdoor scenes will receive light, angle, shade, season, weather and many other variables, requiring more complex and efficient algorithm support, in order to accurately and naturally display the virtual content in reality, the relationship between location, light and shadow effects, to form a high sense of reality augmented reality effect.

The application of head wear devices combined with augmented reality technology at the site, the need to wear head wear devices in the outdoor environment does not affect the viewing of the original appearance of the site, and to achieve a high virtual content rendering effect, thus putting forward higher optical technology requirements for head wear devices. First of all, from the viewpoint of field of view, most of the sites are open scenes, the effective field of view provided by the head wear devices is too low, which will bring the experience of virtual content and realistic scenes of the sense of fragmentation. In addition, from the perspective of optical principle, as shown

in Table 2, by analyzing the optical solutions of a variety of AR headset devices in the market, it is concluded that they are all inadequate for outdoor application needs at present, and it is difficult to meet the demand of high-quality experience.

Optical scheme	Representative products	advantage	shortcoming
Array optical waveguide/ geometric optical waveguide	1.Rokid Glass2 2.Rokid Vision2 3.Leion Pro	Good uniformity, low power consumption , no light leakage, large FoV	The process is complex and the mass production is difficult
Holographic optical waveguide/ diffractive optical waveguide	1.HoloLens 2.Rokid Vision 3.Vuzix blade	High brightness, high resolution and high transmittance	Poor contrast, immature technology
sculptured surface	1.Epson BT-300/350 2.Epson BT-40/40S 3.Rokid Glass	Low cost, large FoV, high resolution	Lens thickness
birdbath	1.Lenovo G2 light 2.Am glass 3.Nreal Light	Low cost, large FoV, high resolution	Thick lens, low light transmittance

Table 2. Analysis of optical scheme of AR headwear equipment.

For the future of cultural heritage digital construction gradually increase, a large number of virtual content generated, digital collections, virtual relics, and digital museums will gradually become the mainstream of the field of cultural and museum products. AR technology, as a means of presentation, will have a broad application prospect in the field of culture and archaeology based on the continuous innovation of underlying technology and application scenarios, promoting efficient interpretation and dissemination of cultural heritage while promoting effective protection, thus giving new vitality to human history and culture.

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