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Research Article

The Construction and Application of a Cloud Editing Digital Museum Oriented to Virtual Tour

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The COVID-19 pandemic has accelerated the digital transformation of museums, and online virtual tours have become an important development direction for the cultural inheritance of museums in the present and future. Therefore, there is an urgent need for appropriate digital museum spaces to attract virtual tours of visitors. Firstly, the paper introduces the current situation of the digital transformation of museums around the world under the background of the COVID-19 pandemic and analyzes the challenges of digital museums in supporting virtual tours. Secondly, aiming at these challenges, we design a cloud editing digital museum architecture and develop a cloud editing digital museum system based on the requirement survey. Finally, the paper introduces the application cases and effects of the cloud editing digital museum system, such as the Zhejiang University History Museum and the China National Silk Museum, and analyzes them with the SWOT method. The SWOT analysis shows that the cloud editing digital museum has advantages in the virtual tour, such as the rapid construction of virtual museums, cost savings, update and maintenance, gamification experience, multiterminal support, immersion and fun, and maintaining visitors' loyalty. It can provide a reference for museums' digital transformation research and cultural inheritance applications.

1. Introduction

At the end of 2019, the emergence of COVID-19 led to the closure of museums in various countries, which seriously hindered the dissemination and inheritance of museum cultural heritage worldwide. The European Museum Organizations (NEMO) research report shows that the museum revenue of 48 countries has lost 75-80% from March to April 2020. Digital transformation has become an important way for museum development. More than 50% of museums have started offering digital museum services [1], two-fifths of museums have seen an increase in online visits between 10% and 150%, and more than 40% of museums responded to the need for help establishing a "digital strategy" [2]. The 2020-2021 survey report of the International Council of Museums (ICOM) shows that global museums are experiencing the worst crisis in modern history. In May 2020, 95% of museums were closed, and 13% of curators feared permanent closure [3]. As a result, global museums have gradually begun offering visitors online virtual tours. Digital museums have been launched one after another. Due to the rapid increase in visits to digital museums during the closure period, 75% of museums plan to improve their digital services, and 77% plan to restructure their digital strategies [4].

However, with the deepening of the online application of digital museums, different types of digital museums have gradually exposed many problems. For example, in the operation of museums, there are many problems, such as difficulty in development, high cost, inconvenience in updating, and maintenance. In terms of virtual tours, there are some problems, such as a lack of immersion, fun, and social interaction, which lead to the low attraction of many digital museums to visitors, and it is difficult to maintain visitors' loyalty. These deficiencies have a particular impact on museums' digital transformation and cultural transmission.

How to improve the design architecture of digital museums, realize the efficient construction of digital museums, provide virtual tours full of stickiness, and maintain the loyalty of visitors has become an important issue that urgently needs to be considered by current museum institutions.

2. Literature Review

2.1. Digital Museum and Virtual Tour. The digital museum is a digital extension of a museum in an online space, a museum without walls [5]. It provides experience with historically, scientifically, and culturally significant images, sounds, texts, and other pieces through digital media [6]. Compared with traditional museum, digital museum has obvious advantages: it can vividly present cultural heritage without the loss or ruin of cultural relics, the management and maintenance are convenient, the construction cost is much lower, the visiting is not limited by time and space [7], and increasing visitors like to visit digital museums [8, 9]. Digital museums are usually constructed using web exhibitions, 360 panoramas, and virtual reality technology. As early as 2004, the Louvre Museum has successively developed digital museums, and the number of Louvre digital museum visitors even exceeded that of the physical museum in 2012. In view of the advantages of the digital museum, in 2011, Google launched the Google Art Project, and a large number of web pages and 360 panoramic digital museums such as the National Palace Museum in Taipei, the Alte Nationalgalerie in Berlin, the Palace of Versailles, and the National Gallery of Britain were created. This caused a momentous shift towards spreading virtual tours for museums [10]. In 2012, Baidu launched the Baidu Baike Museum plan to display the knowledge of museum collections in a panoramic manner through text, pictures, sound, roaming, and other ways. The project has been released to 596 digital museums, including the National Museum of China, the China Geological Museum, and the Shanxi History Museum, serving 160 million visitors and supporting the digital dissemination of Chinese cultural heritage. Moreover, some museums, such as the Palace Museum of China, the Museu d'Arqueologia de Catalunya-Ullastret in Spain [11], and the Very Museum of Milan in Italy [12], use virtual reality technology to simulate real museum visits, which further enhances the virtual experience of visitors. During the COVID-19 pandemic, digital museums have become a meaningful way to spread museum culture worldwide.

2.2. The Challenges of Digital Museum. However, with the large-scale application of digital museums during the pandemic, several problems have been exposed, which directly affect visitors' visiting experience and loyalty maintenance [13]. For example, digital museums in the form of web pages lack a highly immersive three-dimensional environment, which is challenging to attract visitors' interest [14, 15]. The viewing angle and exhibit presentation form of 360 panoramic digital museums are fixed, which limits visitors' viewing experience [16]. The development process of a 3D digital museum is complex, and the cost is high, so it is difficult to form a virtual-real integration ecology for deployment [17, 18]. Many researchers put forward suggestions for redesigning digital museums. For example, the research of Guo et al. and Skulimowski and Kayumov shows that using VR technology to simulate museum tours can enhance the immersive experience of visitors [19–21]. The research of Vermeeren et al. shows that the ecology of digital museums centered on the community can better meet market demand for enhanced experiences [22]. The research of Fernandez-Lores et al. and Giannini and Bowen shows that social networks and virtual communities play a significant role in visitor footfalls in museums [23, 24]. The research of Kuznetcova et al. shows that multiuser virtual environments positively affect people's emotions, motivational responses, knowledge acquisition, and achievement [25]. Therefore, how to redesign digital museums, improve digital services, and support visitors' virtual tours with low cost, high efficiency, convenience, and stickiness has become an urgent key issue to be solved in the field of museum research.

With the further development of virtual reality technology, increasingly mature VR software such as Unity3D and Unreal has brought more efficient and convenient application development modes for developers. Affordable VR headsets such as Oculus and HTC have brought more realistic virtual experiences to visitors. The features of virtual reality, such as multiuser, immersion, interaction, social, coconstruction, and variety of content, are fully used in game design and are favored by people. For example, Roblox, an online game platform, has 199 million monthly users [26]. In China, the "King of Glory" game platform has more than 500 million registered users in 2022 and is popular among users of different ages [27]. These features are lacking in most current digital museums. Therefore, it is essential for museum builders to understand why virtual reality is rooted in users' lives so as to create digital museums to enhance visitors' tour experiences.

3. Materials and Methods

In this section, based on the suggestions from the literature review regarding digital museum improvements, we initially conducted a questionnaire survey to gather actual data on the enhancements needed for digital museums. Subsequently, based on user requirements, we proposed the architecture of a cloud editing digital museum (CEDM). Then, using this design architecture, we developed a CEDM system. Finally, we employed the SWOT analysis method to discuss and analyze the application of the CEDM system.

3.1. The Demand Analysis of Digital Museum. The literature review introduces some researchers' suggestions for redesigning digital museums. In order to understand the museum institutions and visitors' real requirements, we used Likert scales to design the digital museum questionnaire based on the rapid construction of digital museums, user immersive experiences, communication and social interaction, etc. We conducted a survey on 30 managers of museum institutions and 300 visitors with digital museum experience and recovered 30 valid questionnaires from users of museum

institutions and 288 valid questionnaires from visitors, as shown in Table 1.

From Table 1, the average score of all indicators is greater than three points. Most museum managers strongly agree with the digital museum's cluster construction, venue space selection, free exhibition arrangement, resource transactions, upload, management, and maintenance of exhibit resources. Most visitors agree that VR simulation museums can enhance the immersive experience of visitors more than panoramic and web pages. They believe that the digital museum should have some functional indicators, such as support for multiuser and virtual avatars, real-time communication, and social interaction; support for 3D models, text, pictures, sound, video, and other diversified content presentations; and support for Oculus, HTC, and other VR immersion devices.

3.2. The Architecture Design of Cloud Editing Digital Museum. Based on the questionnaire, indicators with an average score of more than three were included in the design of the digital museum. Thus, we propose the design architecture of a CEDM, as shown in Figure 1. The architecture consists of three parts: the base layer, the application layer, and the management layer.

3.2.1. The Base Layer. The base layer mainly provides the basic operating environment for the CEDM, such as the resource library and database, and provides the internet access operation of the CEDM system through cloud services. In the resource library, avatars, gallery templates, 3D exhibits, pictures, video, and sound are mainly stored. The database mainly stores registered user data, user's avatar data, exhibit transaction data, museum access data, social interaction data, and opened museum data. In addition, it also includes the exhibition layout data of the museum, such as 3D models, pictures, textures, audio and video, and text introductions. The museum resources in the resource library correspond to the users and exhibition data in the database, jointly supporting the users of museum institutions to complete the construction and exhibition arrangement of the digital museum, which further assists the visitors in visiting the digital museum and supports the super administrator to complete the management operation of the entire CEDM.

3.2.2. The Application Layer. The application layer mainly includes two modules for museum managers to build the digital museum and for visitors to visit the digital museum.

(1) The Construction of Digital Museum. Firstly, the museum institution obtains permission to construct the digital museum by registering managers and applying to open the museum. Secondly, museum managers can manage their personal resource library, upload and delete 3D exhibits, pictures, videos, sounds, and other resources, and edit the text introduction of exhibits. Then, museum managers can freely select and combine different exhibition halls in the CEDM to build the virtual space of the digital museum. Finally, museum managers add exhibit resources from their personal resource library to the virtual space of the digital museum; drag and drop, rotate, and scale 3D exhibits; set text, video, and sound introductions to complete the online exhibition; and automatically generate the digital museum. In addition, museum managers can also purchase exhibits among themselves to enrich the contents of their digital museum.

(2) Visiting the Digital Museum. First, visitors register their personal information and select avatars to become users of the digital museum. Second, registered visitors can visit all the digital museums with avatars. Third, visitors can interact with the exhibits in the digital museum, such as through voice dialogue and animation interaction with virtual exhibits, to make them immersive into the exhibition story so as to enhance the user experience. Fourth, visitors can communicate with each other in the digital museum and consult the museum guide for more exhibition knowledge. Finally, visitors can share their favorite exhibition content on social platforms to attract more visitors to experience the virtual tour. In addition, visitors can apply to open their own museums to spread their collections.

3.2.3. The Management Layer. The management layer provides management services to the museum institutions and visitors of the CEDM through the super administrators. In this layer, the museum super administrator not only needs to review the registered user information, process the users' application for opening and closing the digital museum, upload and update the gallery templates of the CEDM, and upload the avatars that visitors can select, but also resolve the disputes over exhibit transactions and solve the technical faults encountered by users in a timely manner. To ensure the stable operation of the entire CEDM system, in addition, it is necessary to solve the technical failures encountered by users in a timely manner to ensure the stable operation of the entire CEDM system.

3.3. The Construction of Cloud Editing Digital Museum. Based on the design architecture of the CEDM, we use the relevant software platforms, plug-ins, and languages in Table 2 to develop the CEDM system except for exhibit trading function (because online trading is restricted by government policy approval). The operating principle of the system is shown in Figure 2.

3.3.1. The Technical Implementation of the Base Layer. In the base layer, AppServ and SmartFoxServer in Table 1 need to be deployed to the cloud to provide cloud service support for the CEDM. AppServ mainly integrates an Apache Web server, a MySQL database, and a PHP parsing engine. Apache responds to all operations of super administrators, museum managers, and visitors on the CEDM, such as management, registration, exhibition arrangement, and tour, through PHP pages in the cloud. The PHP engine is used to parse all the PHP program pages sent by Apache, respond to the user's request, and cooperate with the file server and MySQL to operate the files and data in the CEDM. The file server in Apache is used to respond to the request to store all the file resources such as web pages, models, pictures, and videos in the CEDM. MySQL is used to store all data

Table 1: A survey on the need for a redesigned digital museum.

Respondents	Survey indicators	Strongly agree (5 points)	Agree (4 points)	Not sure (3 points)	Disagree (2 points)	Strongly disagree (1 point)	Average score (3 points)
Museum managers	The digital museum supports large-scale and cluster construction.	9	10	5	4	2	3.7
	The digital museum supports the choice of venue space and the free arrangement of exhibitions.	18	8	2	2	0	4.4
	The digital museum supports users in uploading, managing, and maintaining exhibit resources.	25	3	2	0	0	4.8
	The digital museum supports resource transactions.	8	12	7	3	0	3.8
Visitors	The VR simulation of the digital museum enhances the visitors' immersive experience more than panoramas and web pages.	102	95	33	45	13	3.8
	The digital museum should support multiuser and avatars.	135	112	24	15	2	4.3
	The digital museum should support real-time communication and social interaction.	127	109	28	16	8	4.1
	The digital museum supports 3D models, text, pictures, sound, video, and other diverse content presentations.	89	112	54	21	12	3.9
	The digital museum supports sharing tours with mainstream social software.	123	92	35	28	10	4.0
	The digital museum supports VR immersion devices such as Oculus and HTC.	74	98	69	35	12	3.6

requests for users, resources, exhibitions, management, communications, and so on in the CEDM. The SmartFoxServer receives Avatars' communication and interaction data requests and broadcasts them to all users, realizing multiuser virtual communication and interaction in the digital museum.

3.3.2. The Technical Implementation of the Application Layer. The application layer mainly aims at two parts: online exhibition arrangements for museum managers and museum tours for visitors. Museum managers send museum construction requests to the exhibition arrangement system through PHP program pages, which mainly include user registration, personal information management, personal resource library management, exhibit resource uploading, gallery template selection, arranging exhibitions, and releasing the digital museum. The exhibition arrangement system sends a system request to the Apache server and works with the PHP engine to modify the data in MySQL and operate the files in the file server. Apache will feedback the server response to the exhibition arrangement system, and the system will present the response results to the museum managers to update and generate the digital museum. Visitors send tour requests to the digital museum through PHP program pages, which mainly include user registration, personal information management, avatar tour, avatar exchange and interaction, and sharing. The digital museum sends a system request to Apache to cooperate with the PHP engine to modify the personal data in MySQL and load the museum manager exhibition arrangement data in MySQL and the exhibits file in file server. Apache will feedback on the server response to the digital museum, and the system will present the response results to visitors. The digital museum sends an avatar interactive broadcast request to the SmartFoxServer, which broadcasts the interactive operation response of all avatars to the CEDM and presents it to all users in the same museum.

Based on the above principles, we implement the application layer. First of all, the PHP program page is written to realize the functions of museum managers and visitors' registration, user information management, and personal resource library management. Secondly, PHP program pages are written to enable museum managers to upload various 3D exhibit models, pictures, audio and video resources, and select templates for the gallery. Thirdly, the Unity3D engine is used to integrate a professional TriLib plug-in to realize the dynamic loading of 3D models, pictures, audio, and video specified by museum managers in the template of the gallery. Fourthly, C# is used to write programs for drag and drop, rotation, scaling, texture replacement of 3D exhibit models, avatar multiuser interaction connected to the SmartFoxServer interface, and an integrated Oculus integration plug-in. In this way, functions such as online exhibition arrangements for museum managers, Oculus device tours for visitors, and multiuser interaction can be realized. Fifthly, Unity3D is used to package and publish the online exhibition system in WebGL format that supports multiple terminal accesses. Finally, the PHP program page is written to realize the function of automatically updating and generating the digital museum for visitors to visit after the museum managers finish the exhibition arrangement. Different museum managers generate a large number of different digital museums through their identity IDs and eventually form a museum cluster.

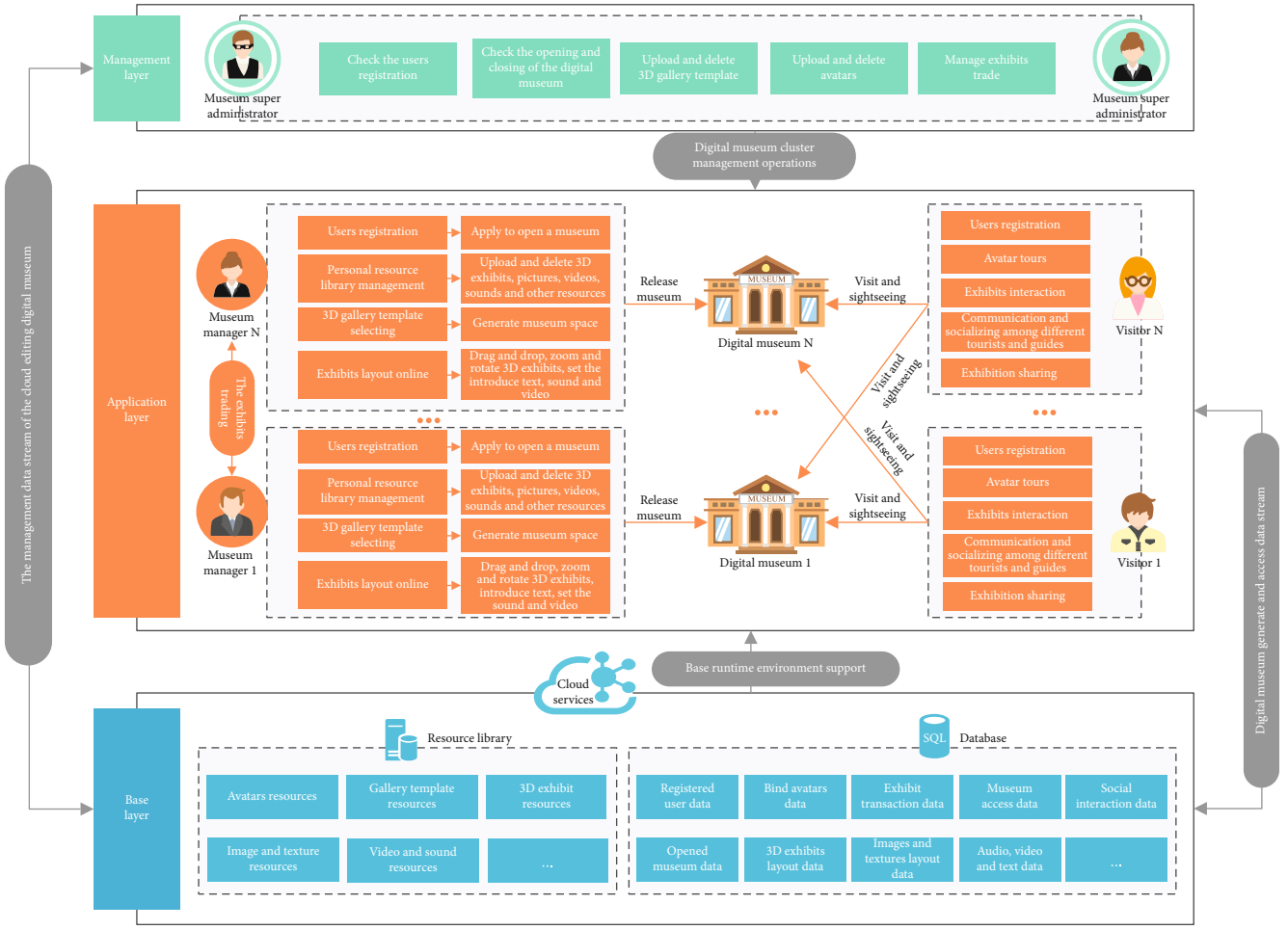


Figure 1: The design architecture of the cloud editing digital museum.

Table 2: The software catalog related to the construction of the CEDM system.

Name	Introduce
Unity3D	Extend the power of the platform for professionals to create and operate interactive, real-time 3D content, 3D games, & experiences.
TriLib	TriLib is a cross-platform runtime 3D model importer written entirely in C#. FBX, OBJ, GLTF2, STL, PLY, 3MF, and ZIP files support. Cross-platform: Windows, Mac, Linux, UWP, Android, WebGL, and iOS. Import models from a file system, the web, or any custom source.
Oculus integration	The Oculus integration brings advanced rendering, social, platform, audio, and avatar development support for Oculus VR devices and some OpenVR-supported devices.
SmartFoxServer	SmartFoxServer is a comprehensive SDK for rapidly developing multiplayer games and applications with Unity, HTML5, iOS, Android, Java, Universal Windows Platform, Adobe Flash/Flex/Air, C++, and more.
PHP	A popular general-purpose scripting language that is especially suited to web development. Fast, flexible, and pragmatic, PHP powers everything from your blog to the most popular websites in the world.
C#	C# is an object-oriented, component-oriented high-level programming language derived from C and C++ released by Microsoft. It runs on the .NET Framework and. NET Core (fully open source, cross-platform).
AppServ	Many people in this world have problems when installing Apache, PHP, and MySQL because they take a long time to configure and sometimes can make them dizzy. AppServ is a full-featured version of Apache, MySQL, PHP, and phpMyAdmin. You can setup in 1 minute.

3.3.3. The Technical Implementation of the Management Layer. In the management layer, PHP language is used to write the management backstage system, which supports the super administrator to manage the users and resources of the CEDM system. The super administrator of the CEDM sends management requests to the management backstage

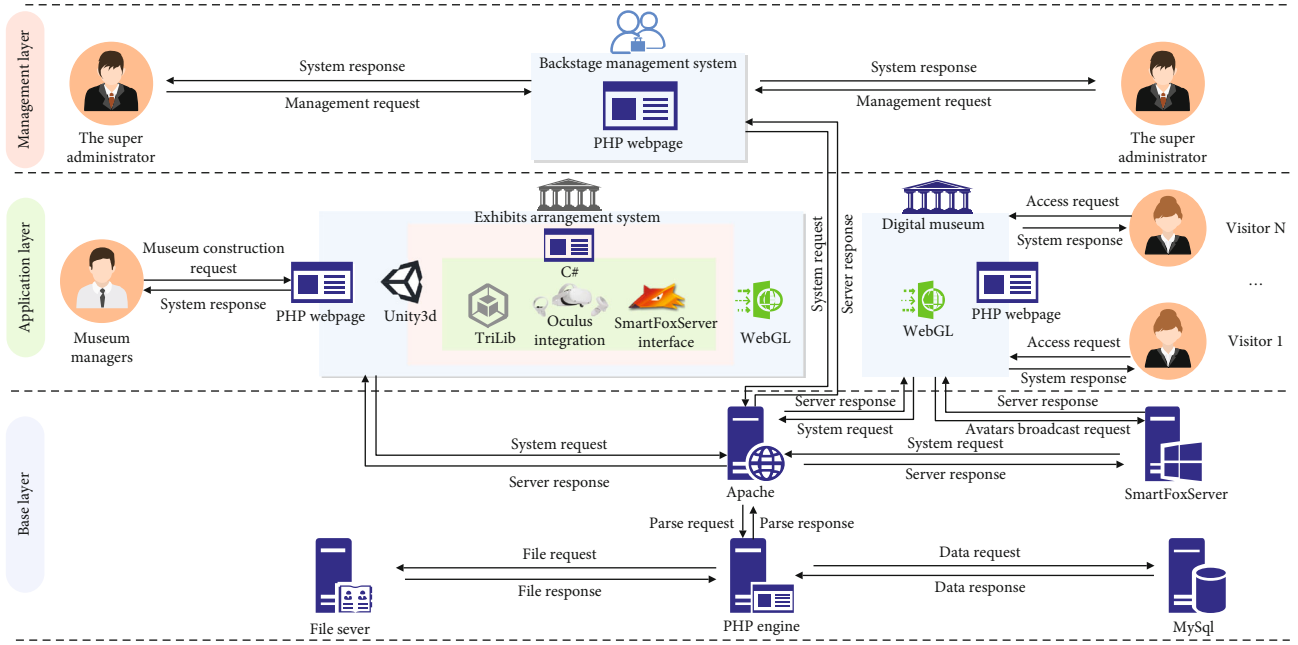


Figure 2: The operation principle of the CEDM.

through the PHP program page, which mainly includes checking user registration, checking the construction application of the digital museum, uploading and deleting 3D gallery templates, and uploading and deleting avatars. The management backstage sends a system request to Apache, and the PHP engine works with Apache to complete the data management in MySQL and the file operation in the file server. The Apache sends the operation result to the management backstage, and the management backstage displays the response result to the super administrator to manage the entire system.

3.4. The Analysis of Cloud-Edited Digital Museum Application Based on SWOT. The SWOT analysis has become a widely used strategic planning tool, designed to help individuals or organizations identify and understand their internal strengths and weaknesses, as well as external opportunities and threats [28]. This analysis is valuable for decision-making, strategy formulation, or pinpointing areas for improvement. SWOT is an acronym for the following four terms: strengths: characteristics or attributes that give an advantage to a business or project. Weaknesses: internal limitations that might hinder the success of a business or project. Opportunities: external environmental factors that could be advantageous for the business or project. Threats: external environmental factors that could pose a risk to the business or project [29–31].

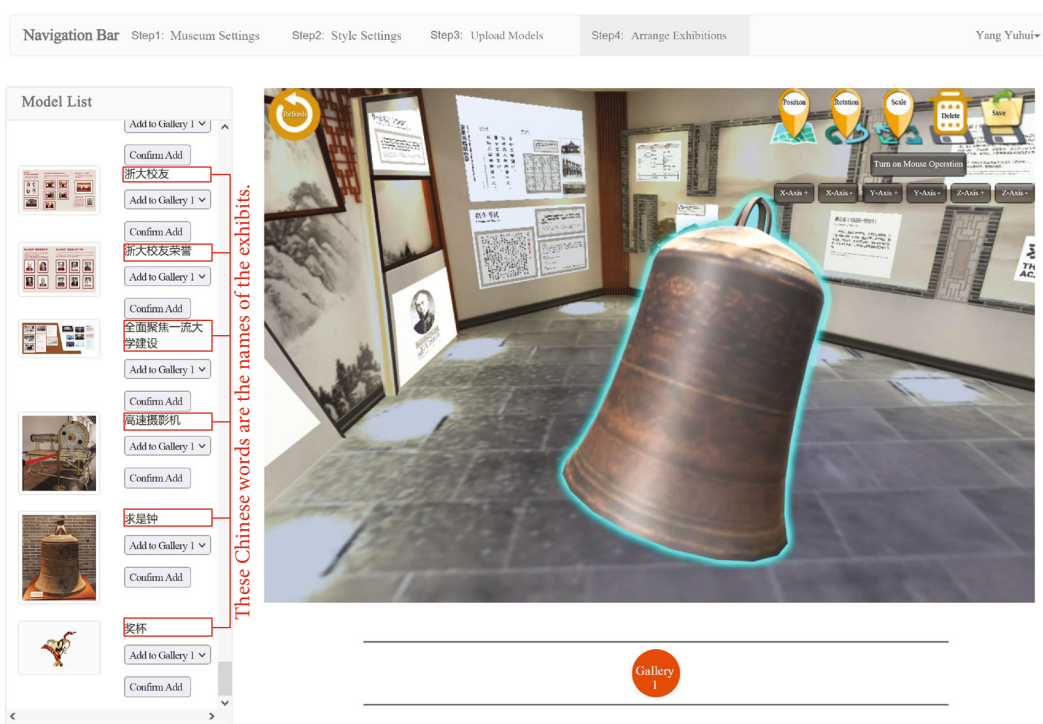
By conducting a SWOT analysis, organizations can better understand their current position, determine potential strategies and directions, and formulate action plans to achieve their objectives. This method has been widely applied in various fields, including strategic planning for corporations, cities, and even countries. We adopted this method in the "Discussion and Conclusions" section, providing a detailed analysis and discussion on the application and development of the CEDM from the four dimensions of strengths, weaknesses, opportunities, and threats.

4. Results

4.1. The Application of Cloud Editing Digital Museum. We have applied the CEDM in 10 museums, such as Zhejiang University History Museum, China National Silk Museum, Silk Road Museum, Sky Sampling Museum, A Flower, A World Museum, White Elephant Tower Story Museum, Gentleman Values Virtue Museum, Guqin Museum, and Lacquerware Exhibition Hall, to explore the enhanced experience of visitors. The following is an introduction to the History Hall of Zhejiang University and the application of silkworm weaving drawings in the China National Silk Museum.

4.1.1. The Zhejiang University History Museum. The account of the Zhejiang University History Museum has been registered in the CEDM. The users uploaded more than 200 pieces of display boards and 3D cultural relic models with five themes: seeking truth from the source, exploring the rise, adjusting development, striving for first-class, and adding corresponding text introductions, as shown in Figure 3(a). After the user selects the gallery template, add the school history exhibits to the gallery template in the personal resource library and complete the arrangement of the school history museum by dragging and dropping, rotating, and zooming. The system automatically updates and releases the digital school history museum, as shown in Figure 3(b). Students carry out school history digital inheritance activities with the help of the digital school history museum. On the one hand, the registered students use the computer to enter the Zhejiang University History Museum from the main page of the CEDM system to freely choose the tour

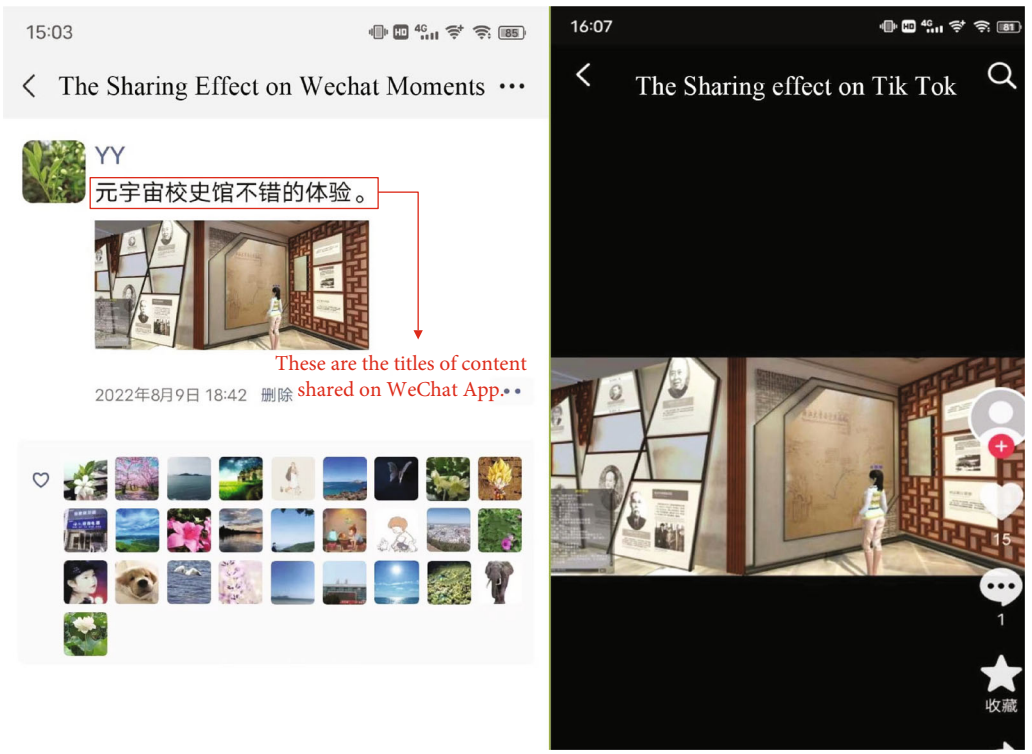
(a)



(b)

Figure 3: Continued.

(c)



(d)

Figure 3: (a) Users upload exhibits to the school history museum. (b) The arrangement of exhibits in the school history museum. (c) Students visit the school history museum. (d) Students share exhibitions on social platforms.

route; on the other hand, they use personal avatars to watch the content of school history from the perspective of the third person, click the display board to view more detailed content, and carry out communication activities with each other, as shown in Figure 3(c). Finally, students use social software such as WeChat and TikTok to capture wonderful content and share it in moments to obtain the likes and recognition of their partners, so as to carry out cross-platform cultural digital inheritance activities, as shown in Figure 3(d).

4.1.2. The Silkworm Weaving Drawings Museum. The Silkworm Weaving Drawings Museum belongs to the China Silk Museum. The "Silkworm Weaving Drawings" is a famous painting by Lou Xuan, a painter during the Shaoxing period of the Southern Song Dynasty. The museum dynamically simulates the "Silkworm Weaving Drawings," showing the process from farmers raising silkworms to the silk being woven into silk fabric. In the CEDM, the account of the Silkworm Weaving Drawings Museum is registered, and museum managers upload 8 animation scenes such as cutting mulberry leaves, warming silkworms, feeding silkworms with mulberry leaves, building straw bushes for cocoons, boiling cocoons and drawing silk threads, sorting silk threads, winding silk threads onto the warp axis, weaving silk threads into cloth to the resource library, and adding the corresponding voice and text introduction, as shown in Figure 4. The user selects the gallery template and adds eight animation scenes to the gallery template in turn to complete the online arrangement of the museum and automatically generate the digital museum. In order to get a better user experience, the China National Silk Museum once opened Oculus Rift equipment for free to visitors in order to get immersive tour services in the Zhejiang art exhibition. In the Silkworm Weaving Drawings Museum, visitors wear the Oculus, use the handle to switch the scenes, watch the animation process from silkworm rearing to textile, listen to the voice explanation, and complete the virtual experience, as shown in Figure 5.

4.2. The Experience Feedback. We investigated the application effect of CEDM museum from two dimensions: museum managers and visitors.

4.2.1. The User Experience Feedback on the Construction of the Digital Museum. In order to obtain user experience feedback on the construction of a digital museum, we designed a questionnaire based on a 5-point Likert scale. A survey was conducted among 30 users who used the CEDM to construct the digital museum, and 30 valid questionnaires were recovered, as shown in Figure 6. The survey results show that 77% of users believe that the construction of the digital museum is simpler and more efficient than the traditional virtual museum built with web pages, 360 panoramas, and virtual reality technology. 87% of users believe the construction of the digital museum is more cost-effective. 83% of users think the digital museum is easier to update and maintain. 77% of users think the digital museum's virtual tour simulation is more realistic. 80% of users prefer to use the CEDM.

4.2.2. The Visitor Experience Feedback from the Digital Museum. In order to obtain the satisfaction of visitors' experiences in the digital museum, we designed a questionnaire based on a 5-point Likert scale. 220 visitors who have experienced the CEDM were selected to conduct a questionnaire survey, and 205 valid questionnaires were recovered, as shown in Figure 7. The survey results show that 87% of visitors are satisfied with the clustered presentation of the digital museum. 83% of visitors were satisfied with the multiuser avatar experience in the digital museum. 91% of visitors were satisfied with the immersive and fun nature of the digital museum. 79% of visitors were satisfied with the social interaction in the digital museum. 76% of visitors were satisfied with the multiple terminal experiences of the digital museum. Overall, 82% of the visitors were satisfied with the digital museum tour experience. 81% of visitors were satisfied with the sticky attraction of visiting the digital museum.

5. Discussion and Conclusions

Under the background of digital transformation, in order to help museum institutions realize digital strategy, meet the needs of visitors' immersive tours, and explore the digital heritage path of museum culture, we proposed the CEDM architecture and developed the CEDM system based on the analysis of museum institutions' digital transformation and the survey of visitor needs. Finally, we carried out applied research on the construction of the digital museum for museum managers and virtual tours for visitors. Based on the SWOT analysis, the following section presents the research results and conclusions of CEDM supporting virtual tours in the context of museum digital transformation, as shown in Table 3.

5.1. Strengths. Compared with the digital museums constructed by many museum institutions in China using web pages, 360 panorama, and virtual reality technology, the application result shows that CEDM has the following strengths. In terms of museum construction, since the CEDM is built with space and a template, users do not need programming but only need to upload exhibit resources and arrange exhibitions to complete the construction of the museum. It avoids the disadvantages of repeated construction of traditional virtual natural, so it has the characteristics of low construction cost, simplicity, and efficiency. Without the support of professional technicians, museum managers can quickly modify and replace digital exhibits in the CEDM, which has the advantage of convenient updating and maintenance. In terms of visitor experience, first of all, the CEDM provides visitors with personalized avatars and brings them a gamified tour experience. Secondly, the CEDM provides a social interaction channel for visitors, facilitating communication between visitors and museum institutions and accelerating the inheritance of digital culture. Thirdly, the CEDM supports a variety of terminal tours, such as computer, mobile phone, and Oculus, providing visitors with different levels of tour experience. Finally, the CEDM provides an immersive 3D environment, interesting interactive mechanisms, imaginative simulation of

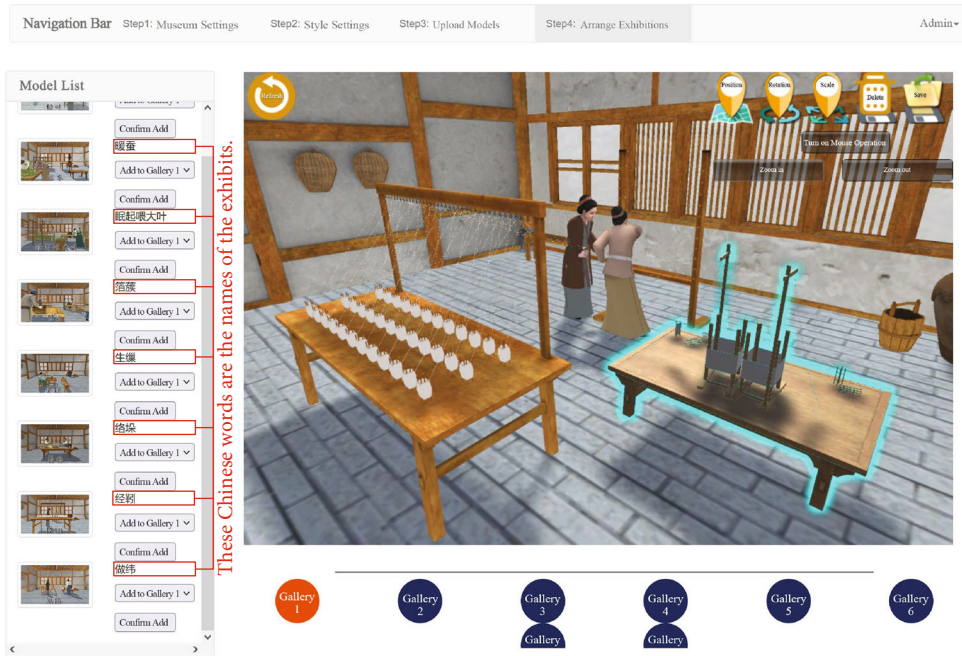


Figure 4: The arrangement of exhibits in the Silkworm Weaving Drawings Museum.

Figure 5: Visitor wears Oculus to visit the Silkworm Weaving Drawings Museum.

the scene, and rapidly updated content to enhance the loyalty of visitors.

5.2. Weaknesses. Firstly, different spatial templates, avatars, social mechanisms, and tour modes in the same cluster are used in the construction and application of the digital museum, which limits the personalized development of the digital museum to a certain extent. Secondly, due to the large number of online visitors, the tour is not limited by time, so it is difficult to provide guide services to meet the needs of different visitor groups and different time periods in the CEDM. Thirdly, as the CEDM involves diverse experiences such as gamified characters, social interaction, resource sharing, 3D roaming, and multiterminal support, visitors are required to have certain information technology capabilities. Fourthly, since the CEDM is highly dependent on

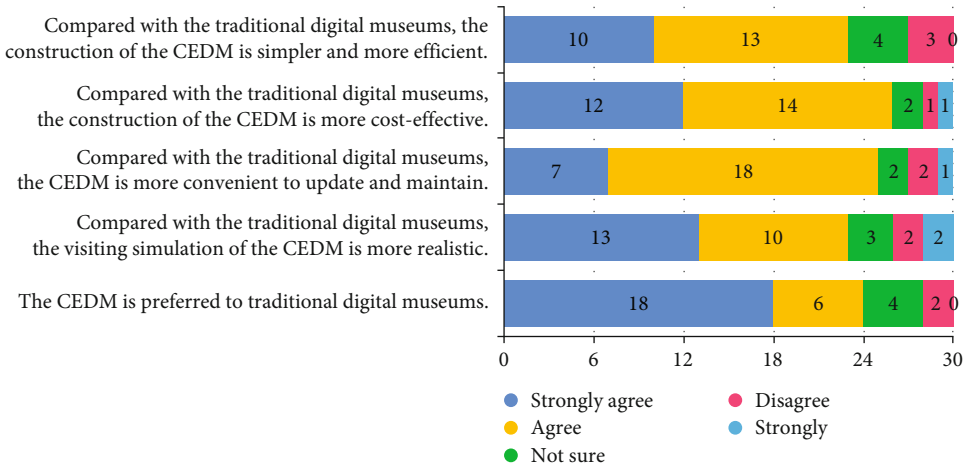


Figure 6: The user experience feedback for the construction of the digital museum.

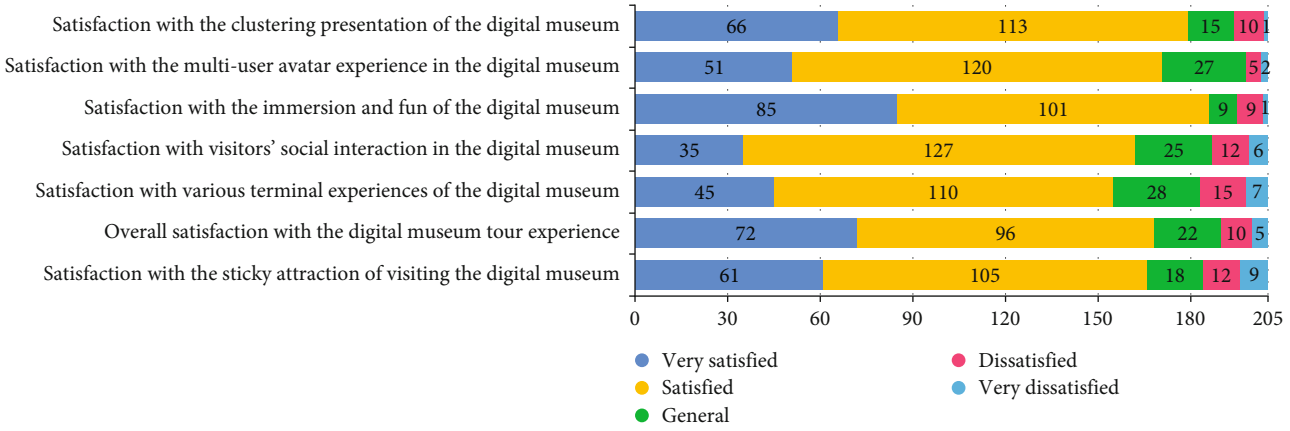


Figure 7: The visitor experience feedback from the digital museum.

Table 3: The SWOT analysis on the CEDM supporting virtual tour.

Strengths	Weaknesses
(i) The construction of the digital museum is simple and efficient (ii) The construction cost of the digital museum is low (iii) The CEDM is easily updated and maintained (iv) Multiuser avatars provide gamified experiences for visitors (v) The CEDM offers social interaction to accelerate cultural heritage (vi) The CEDM provides a variety of terminal support to enhance visitors' experience (vii) The CEDM enhances visitor loyalty by providing immersive, interesting, and imaginative digital means	(i) To some extent, the CEDM limits the personalized development of museum (ii) It is difficult for the CEDM to provide round-the-clock manual guide and consultation services (iii) The CEDM requires visitors to have some information technology skills (iv) The unstable factors of the online environment can easily lead to the catastrophic consequences of the loss of the CEDM resource data (v) The CEDM is no substitute for the real thing
Opportunities	**Threats**
(i) The CEDM can enhance the social interaction experience by integrating mature social software (ii) With the popularization of 3D rapid modeling technology, the construction efficiency of the digital museum will be greatly improved (iii) 5G, VR panoramic live streaming, and other technologies are maturing, and their application in the construction of digital museums has just begun (iv) The CEDM will be equipped with intelligent guides as the accuracy of AI dialogue robots improves (v) There is a strong demand for CEDM in the field of education	(i) The CEDM stores large-scale exhibit data and user data, so network attacks and data leaks are some of the important threats it faces (ii) The digital exhibits in the CEDM are prone to copyright disputes (iii) In the process of application, some visitors who are used to visiting physics museums resist visiting the CEDM

digital resources, the instability of cloud services may lead to the catastrophic consequences of the loss of exhibition resource data, affecting visitors' tour experiences and even the reputation of the museum. Finally, the CEDM cannot replace the physical museum because it is difficult to simulate the real feel of visitors in the physical museum. It can be used as a supplement to the physical museum, forming an online and offline tour mode.

5.3. Opportunities. First of all, with the further opening of social software interfaces such as WeChat, DingTalk, and Tencent Meeting, the subsequent CEDM will integrate mature social software to enhance visitors' social interaction experiences and facilitate the rapid dissemination and sharing of museum resources. Secondly, with the popularization of images into 3D models and 3D model scanning technologies, such as PhotoScan and EinScan, the efficiency of building digital museums by museum managers will be greatly improved. Thirdly, with the further popularization of 5G technology, VR panoramic live streaming will be applied to the construction of CEDM more quickly. It will greatly enhance the virtual and real experiences of visitors in the future. Fourthly, with the popularization of knowledge graphs, machine learning, and other artificial intelligence technologies, the accuracy of AI dialogue robots has been greatly improved. Intelligent tour guides will be applied to the CEDM to customize personalized tour guide services for visitors, so that "knowledge knows you better." Finally, there is a strong demand for CEDM to be applied in schools and universities for museum education.

5.4. Threats. Firstly, the CEDM not only stores a large amount of exhibit data from museum institutions but also a large amount of identity information from visitors. Therefore, the loss of museum exhibit data and the leakage of visitors' private information data caused by cyber-attacks will become an important threat to the CEDM. Secondly, digital exhibits in the CEDM are easy to be photographed, simulated, and reconstructed by visitors or other museums, and then displayed in their own museums, thus causing copyright disputes. Finally, we found that a small number of older visitors who are used to visiting physical museums resist visiting the CEDM during the application process. In view of the above threats, on the one hand, we should strengthen the network security protection of the CEDM; on the other hand, we should try to introduce blockchain technology to clarify the copyright ownership of digital exhibits in the museum so as to solve the copyright disputes. In addition, it is necessary to strengthen the publicity of the CEDM and the online operation training of visitors from the perspective of the integration of virtual and reality.

The practice and exploration of CEDM is a dynamic process, which is evolving with the innovative application of new technologies, the practical needs of digital transformation, and the development trend of cultural inheritance in the future. This paper introduces the current research status of digital museums in the context of museum digital transformation, puts forward the design framework of CEDM, and develops the CEDM system. We take the Zhejiang University History Museum and China National Silk Museum as examples to verify their application effect and use the SWOT method to analyze and summarize them. As CEDM enhance tour modes and experiences in the digital environment, online tours require visitors to have higher information literacy compared with traditional digital museums. In addition, the construction of the CEDM adopts template space, avatar, and social interaction, which to a certain extent affects the personalized development of the digital museum. However, the SWOT analysis shows that CEDM has advantages in the rapid construction of digital museum, cost saving, update and maintenance, gamification experience, multiterminal support, highly immersive and interesting environment, and maintaining visitor loyalty. It can provide a reference for the digital transformation and cultural inheritance applications of other venues. In order to further enhance the human-computer interaction experience of the CEDM and realize the cultural inheritance concept of "edutainment in fun," the application of an intelligent tour guide based on AI human-computer dialogue will become the focus of the subsequent research of the CEDM.

Data Availability

The visitor's experience feedback data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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