Design and implementation of interactive narrative map of Nanjing Ming Dynasty City Wall Based on Mixed Reality

基于混合现实的南京明城墙交互式叙事地图系统设计与实现

Participanting units: Nanjing Normal University

参赛单位：南京师范大学

Content

1 Introduction

"Jiangnan, the beautiful place; Jinling, the imperial Prefecture". Nanjing, the ancient capital of the Six Dynasties, has a profound cultural heritage. The changes over thousands of years have left a rich historical and cultural heritage for Nanjing. The Ming city wall, known as "the world's first city wall", is a legendary example of Nanjing's magnificent historical material wealth. From its majestic standing, you can still see Nanjing's glorious past in its long history. As the core element in the formation of ancient Chinese cities, the city wall is the carrier, symbol, and proof of ancient Chinese urban planning thought, spatial layout, architectural function layout, and the concept of the human-land relationship.

To spread the history and culture of the Nanjing Ming City Wall, it is necessary to reflect on the regional characteristics of Nanjing, explore the cultural attributes of the city wall, and tell the story of the city wall well. As a new branch of cartography, narrative cartography combines the advantages of cartography in the expression of spatial information and the advantages of narratology in the expression of time information. Combining interactive maps with audio and video, it helps people understand the occurrence and development of events in space. In turn, a deeper understanding of the event itself is formed, which also provides a new spatial narrative method for disseminating the history and culture of the Nanjing Ming City Wall. In recent years, how to preserve, inherit and disseminate the architectural cultural heritage represented by Nanjing Ming City Wall through modern scientific and technological means has become so urgent. At the same time, digital cultural heritage technologies supported by computer graphics, virtual reality (VR), augmented reality (AR) and computer animation provide rich means for digital recording, preservation, display, and utilization of cultural heritage.

As a relic of historical civilization, Nanjing Ming City Wall has great historical and cultural value and is a precious building for studying the social development of China's Ming and Qing Dynasties and even the Republic of China. Therefore, it is of great practical significance to study the use of different map media to promote the protection of the Ming city wall. In the convergent media environment, based on mixed reality technology, it is very feasible to integrate electronic map, AR scenario, VR scenario, text, audio, video, and other contents in the narrative map of the Ming city wall of Nanjing, which not only makes the expression content, expression methods and

interaction means of the narrative map more diversified but also provides a reference for the form expansion and dissemination of map products.

2 Research Objectives

Focusing on the research goal of "Design and implementation of interactive narrative map of Nanjing Ming Dynasty City Wall Based on Mixed Reality", based on the theoretical knowledge of cartography, computer science, and art, this work collects and arranges multi-source data such as cultural and historical data of Nanjing Ming city wall, Nanjing ancient map data, and remote sensing data, and uses methods such as literary analysis, mapping element analysis, scenario design, and scenario construction. Taking the scroll for mounting ancient calligraphy and painting in traditional Chinese culture as the narrative carrier, this work integrates electronic map, AR scenario, VR scenario, text, audio, video, and other multimedia content on the unity3d platform to build an interactive narrative map system of Nanjing Ming City Wall. Taking the geographic pattern of Nanjing as the background, combing the temporal and spatial characteristics and historical events of the Nanjing Ming Dynasty City Wall, the pattern of landscape city, and the historical tradition of the city wall closely related to people's lives, the map system displays the historical changes, the imagery, the military functions, the folk customs and other contents of the Nanjing Ming Dynasty City Wall in the expression of interactive narrative map. Through the desktop interactive narrative map, we hope to reproduce the historical style of the Nanjing Ming Dynasty City Wall and spread its history and culture.

3 Innovations

（1）As an important form of traditional Chinese painting, handscrolls contain rich cultural connotations. This research designs an interactive system with hand scrolls as a narrative carrier and draws on its appreciation method of "one collection and one close" to show the historical changes, the imagery, the military functions, the folk customs and other contents of the Nanjing Ming Dynasty City Wall, to reproduce the historical style of Nanjing Ming City Wall. The research further promotes the integration of narrative maps and traditional Chinese cultural elements and deepens the cultural connotation of maps.

（2）Mixed reality integrates human-computer interaction, traditional reality, and human cognition, and has the characteristics of "interactivity", "authenticity" and "multi-perception" stronger than single virtual reality technology or single augmented reality technology. This research constructs an interactive narrative map for Nanjing Ming City Wall based on mixed reality, integrating electronic maps, AR scenario of military function in Zhonghua Gate, VR scenario of Zhongshan Gate sunrising, narrative videos, text, audio, animation, etc., in a variety of ways. The Nanjing Ming City Wall is described and depicted from different angles, which more vividly shows the history and culture of the Nanjing Ming City Wall.

（3）Film is one of the important narrative forms. This study combines maps and films to design and produce a film narrative map of the Nanjing Ming City Wall. The video leads to the narrative subject of Nanjing Ming City Wall through the Nanjing geographic location map and Nanjing topographic map, and then introduces its history and culture based on the interactive narrative map of Nanjing Ming City Wall, which adds a vivid and interesting effect to the work.

（4）The interactive narrative map designed in this research breaks through the static representation of the traditional two-dimensional narrative map visualization. With the help of interactive means such as multimedia interaction, three-dimensional model interaction, UI interaction, and scenario roaming, it enhances users' multi-dimensional understanding of Nanjing Ming City Wall, and thus promotes the protection and dissemination of the cultural heritage of Nanjing Ming City Wall.

4 Research Flow

(1) According to the design objectives, we investigate relevant data and documents, and collect and sort out multi-source data such as cultural and historical data of Nanjing Ming city wall, Nanjing ancient map data, and remote sensing data.

(2) Based on the existing multi-source data, by analyzing the temporal and spatial characteristics of Nanjing Ming City Wall, we built a historical database and geographic landscape database of Nanjing Ming City Wall.

(3) Using the methods of literary analysis, map element analysis, scenario design,

and scenario construction, and with the help of professional drawing tools like ArcGIS and CorelDRAW, and software development tools such as Visual Studio, we carry out hand-rolled map design, AR scenario design of gate military function, VR scenario design, folk custom converged media map design, etc.

(4) Based on the Unity 3D platform, the hand-rolled map, AR scenario, VR scenario, narrative video, text, audio, and other multimedia contents are integrated into an interaction system. The detailed process is shown in Figure 4.1.
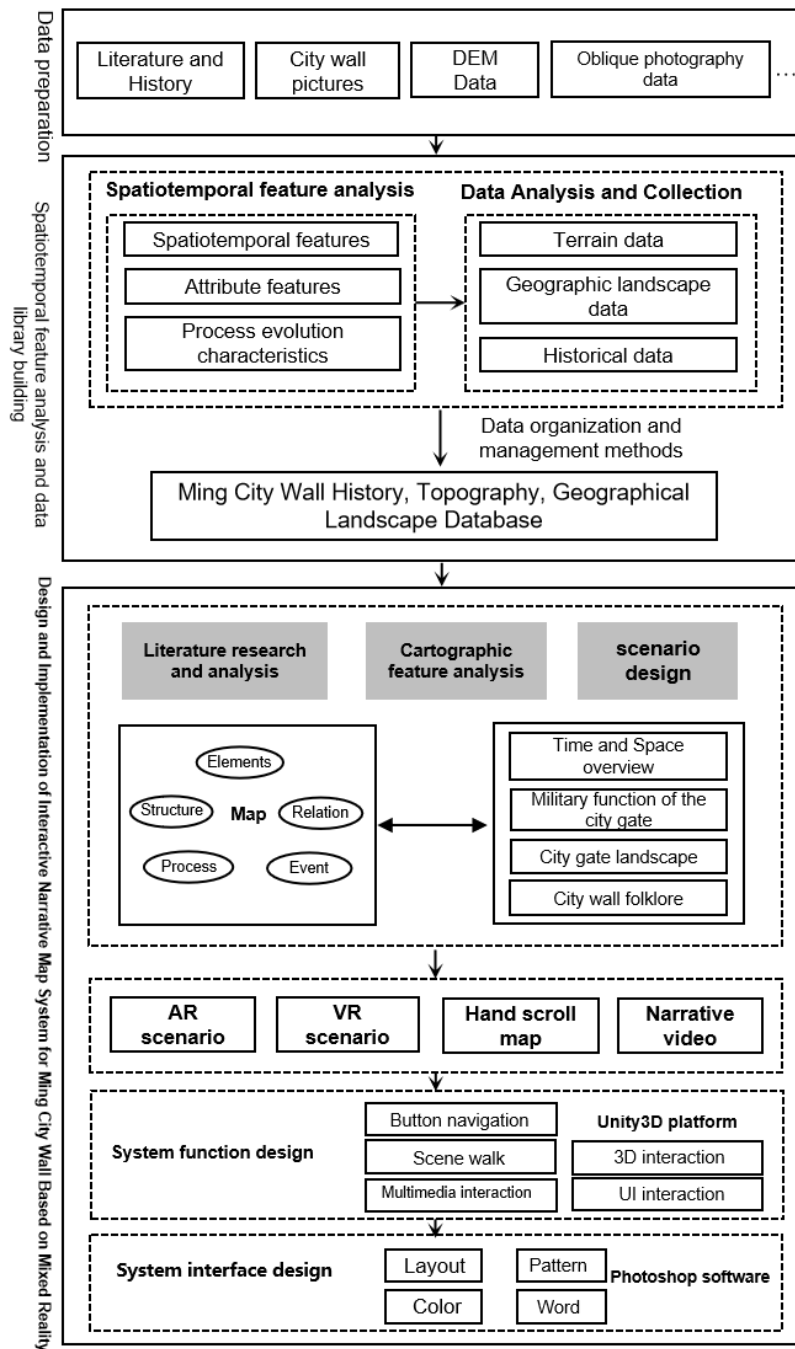

Figure 4.1 Research flow chart

5 Design and implementation of interactive narrative map of Nanjing Ming Dynasty City Wall

5.1 Hand scroll map design

A map is worth a thousand words, and the map is more persuasive and communicative than a single text. Through the narrative map, this research shows the unique architectural layout of the Ming city wall under the geographical pattern of " a forbidding strategic point", which is different from other city walls, and the folk traditions of the city wall are closely related to people's lives.

In the plane composition of the "Hu Ju Long Pan" map (Figure 5.1), one "vertical line" (Yangtze River) and two "horizontal lines" (Qinhuai River and New Qinhuai River) form the skeleton of the map. On the right side of the map are Zhongshan mountain, Ningzhen mountains, Fangshan mountain, and other mountains. The four-circle city wall was built in such a geographical environment. Among them, the palace city wall, the imperial city wall, and the capital city wall were built between the mountains and the river, and the outer city wall was built on the outside of the mountains to further protect the palace city. The overall style of the map draws on the traditional Chinese painting form of blue-green landscape painting. The cyan linear symbol represents the river. The stone-green figurative symbol represents the mountain range. The cyan-gray, light yellow, and light red symbols represent the four-circle city walls. The Ming Dynasty military flag symbol indicates the thirteen gates at the beginning of the construction of the city wall.
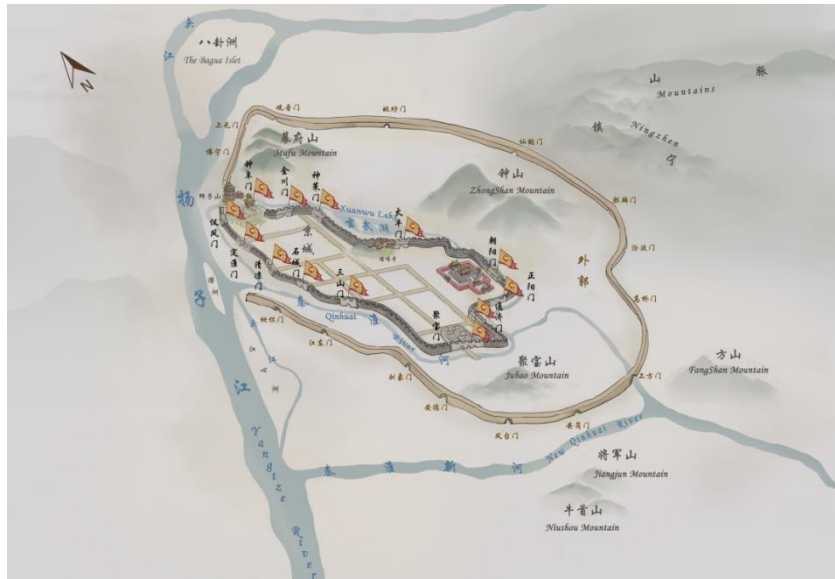
Figure 5.1 " Hu Ju Long Pan" map

The map introducing folk customs takes the traditional custom (Spring Festival, Shangsi Festival, Double Ninth Festival, etc.) as the mainline. According to the place where the people celebrate the customs, traditional customs such as picking shepherd's purse, hanging spring couplets, watching lanterns, and climbing are presented clockwise. The overall map style draws expresses the lively scenarios with bright colors.

Figure 5.2 The map introducing folk customs

The layout of the drawing is like the handscroll, which is the traditional form of Chinese calligraphy and painting. The handscroll is mounted by "Tiantou", "Geshui", "forerunner", "painting center" and "trailing" (Fig. 5.3). Add the Ming city wall elements in the design of the scroll, and take the color cyan gray(the color of the capital city) as the main color, and thus finally determine the handscroll style of the system narrative map.

Figure 5.3 The layout of the handscroll

5.2 AR scenario design of military function demonstration in Zhonghua Gate

In this study, AR technology is used to reproduce the AR scenario of military function demonstration in Zhonghua Gate. AR scenario can provide users with a variety of perspectives, enhance the perspective of reality and virtual characters, and enhance the user's sense of experience. The user can also interact with the fort to enhance the user's sense of participation and interest in the scenario. The AR scenario design has set up corresponding plot modes, so that users can feel the characteristics of the urn structure of the Zhonghua Gate, and strengthen users' impression of the military scenario.
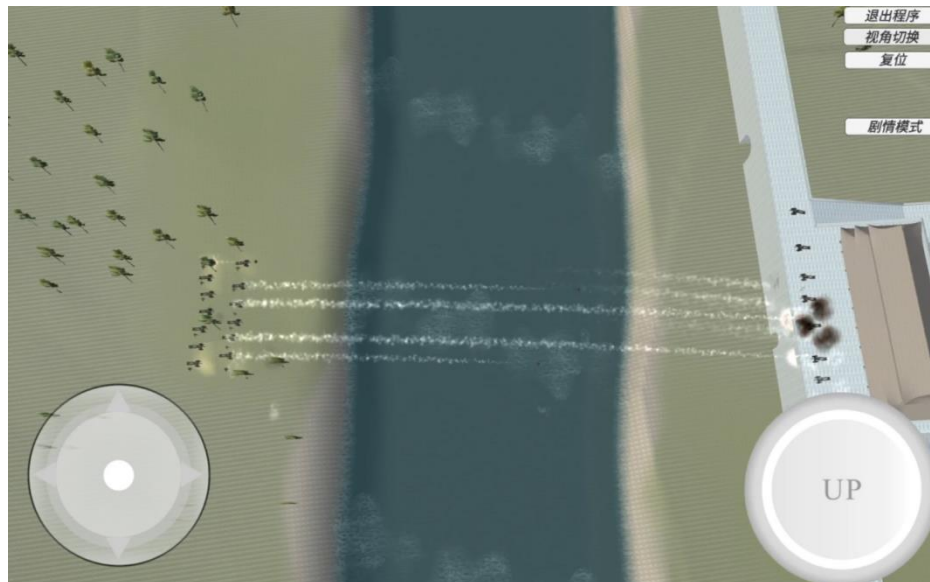

Figure 5.4 AR scenario design of Military function demonstration in Zhonghua Gate

5.3 VR scenario design of Zhongshan Gate sunrising

This study uses VR technology to present the sunrising scenario of Zhongshan Gate. We firstly integrate the maps, images, ancient paintings, and relevant text materials related to the Ming city wall of Nanjing, and further analyze a variety of

7

natural and humanistic imageries. Then, we build a three-dimensional model of Zhongshan Gate and its surrounding landscape in Sketch Up software. Finally, imageries such as sunrising, birds, clouds, and fog are added to Unity3D to express the artistic conception of looking at the emerald scenery of Zhongshan Mountain from the east of the city.

Figure 5.5 VR scenario design of Zhongshan Gate sunrising

5.4 Interactive narrative map design

This study aims to integrate the historical events, gate landscape, gate battle, and folk customs of the Nanjing Ming City Wall on an interactive platform. Combing with the expression of handscroll, we use the Unity 3D visualization engine to develop and implement an interactive narrative map system for Nanjing Ming City Wall based on mixed reality. The framework of the system is shown in Figure 5.6.
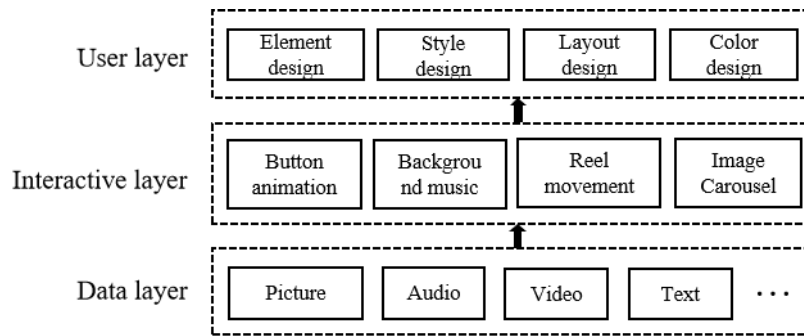
Figure 5.6 System framework

5.4.1 Import multimedia data

After preprocessing, image, audio, video, text, and other data are imported into Unity 3D, as shown in Figure 5.7. When importing an image, select the Texture Type. In this design, the pictures are mainly used as UI, so choose Sprite (2D and UI) type. Considering that the UI is mainly displayed in this interactive system, high-definition pictures are required to support the rendering effect, so we will set the maximum size of the imported pictures to 8192px and the compression rate to be High Quality.
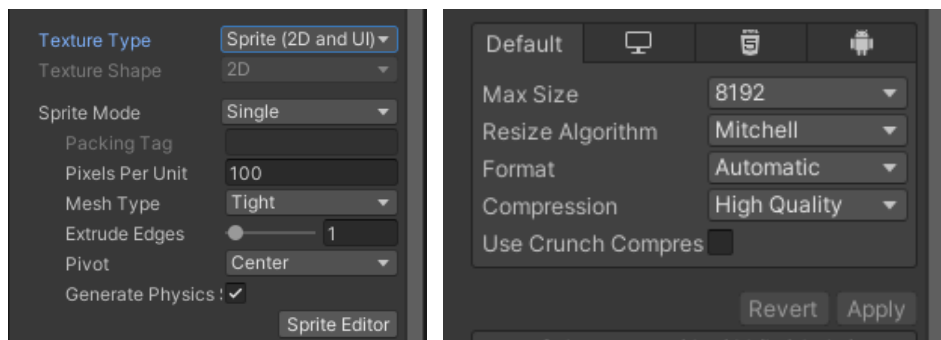

Figure 5.7 Import picture settings

5.4.2 Interaction function design

In the Unity3D visualization engine, buttons are very important for UI interaction, so this study designs the buttons to float up and down and adds the effect of highlighting and changing colors to attract users' attention. Background music can play a role in setting off the atmosphere. For Nanjing Ming City Wall, a cultural heritage with a glorious history of more than 600 years, Chinese classical music is used to enhance the user's auditory interaction. Referring to the concept of ancient Chinese scroll design, this interactive system is expressed in the form of scrolls. When the system is initialized, the reels are unrolled from right to left. After clicking the button to start browsing, the overall content of the scroll slides from left to right, simulating the scenario where the physical scroll expands from right to left, allowing users to experience the effect of

scroll opening as if they were on the scenario. In the Unity3D visualization engine, buttons are very important for UI interaction, so this study designs the buttons to float up and down, and adds the effect of highlighting and changing colors to attract users' attention. Background music can play a role in setting off the atmosphere. For Nanjing Ming City Wall, a cultural heritage with a glorious history of more than 600 years, Chinese classical music is used to enhance the user's auditory interaction. Referring to the concept of ancient Chinese scroll design, this interactive system is expressed in the form of scrolls. When the system is initialized, the reels are unrolled from right to left. After clicking the button to start browsing, the overall content of the scroll slides from left to right, simulating the scenario where the physical scroll expands from right to left, allowing users to experience the effect of scroll opening as if they were on the scenario. For the historical events of the city wall, we use the interactive method of picture carousel, so that users could understand the typical historical events of the Ming city wall.

Figure 5.8 Interactive buttons

5.4.3 Interactive interface design

The theme of this interactive system is to express the Nanjing Ming City Wall, so the system design mostly selects the elements of the city wall to closely follow the theme. The overall style of the system is based on the style of the " Hu Ju Long Pan " map, presenting an elegant ink style. The overall layout design is based on the Chinese scrolls, and is divided into main parts such as "Tiantou", "Geshui", "forerunner", "painting center" and "trailing" (Fig. 6.9).
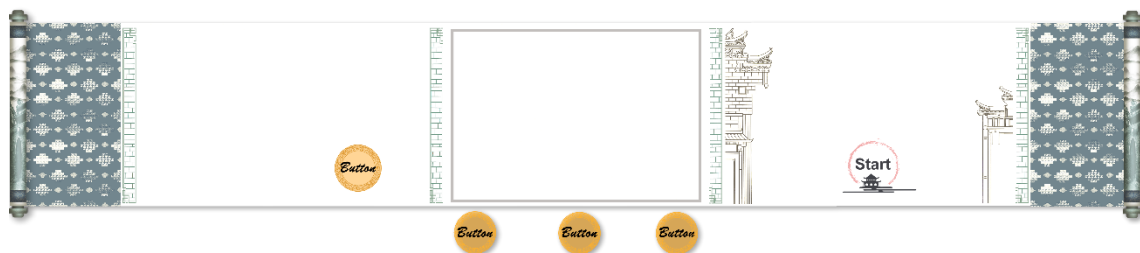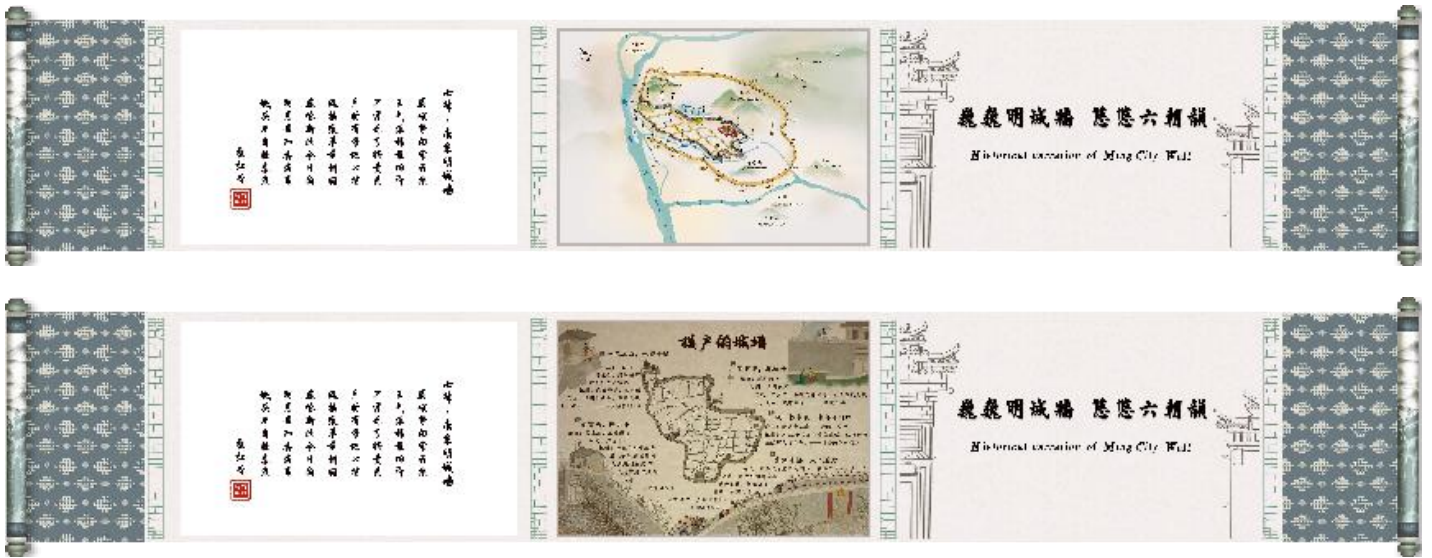

Figure 5.9 Interactive interface design

6 Map Display
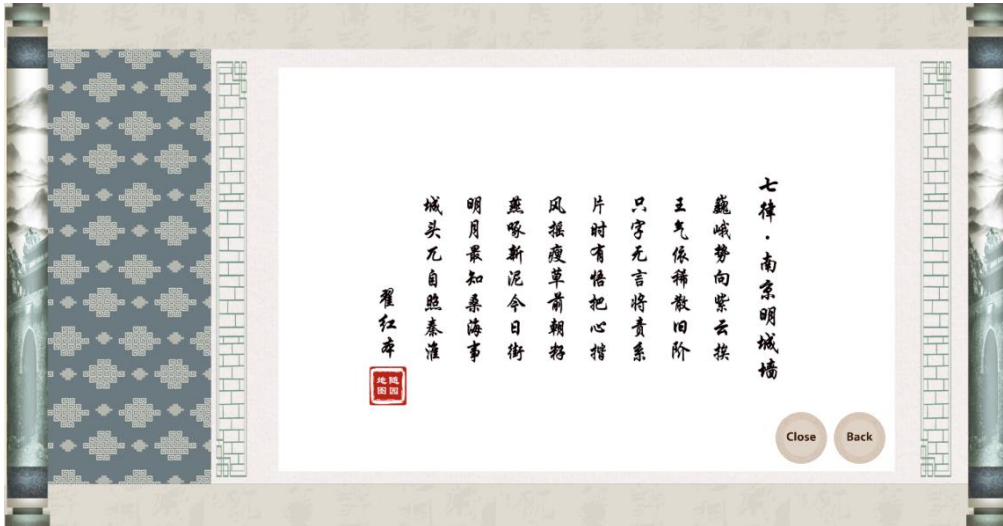

Figure 6.1 Hand scroll map

Figure 6.2 Interactive interface

Figure 6.3 Figure 6.3 Spatiotemporal historical map

Figure 6.4 Gate landscape

12

Figure 6.5 VR sunrising scenario of Zhongshan Gate

Figure 6.6 AR scenario of military function demonstration in Zhonghua Gate

Figure 6.7 Nanjing folk custom exhibition based on multimedia

7 Reference

[1] Yang Guoqing. Nanjing Ming Dynasty city wall [M]. Nanjing publishing press. 2002.

[2] Yang Guoqing. Nanjing city wall chronicle [M] Phoenix publishing press. 2008.

[3] Zhong Linying, Shen Jie, Mao Wei, Wang Menghe, Yu Zhaoyuan. The design and realization of the ancient city narrative map based on spatiotemporal knowledge graph [J]. Journal of remote sensing, 2021,25 (12): 2421-2430.

[4] Biljecki F, Stoter J, Ledoux H, et al. Applications of 3D city models: State of the art review[J]. ISPRS International Journal of Geo-Information, 2015, 4(4): 2842-2889.

[5] Çöltekin A, Heil B, Garlandini S, et al. Evaluating the effectiveness of interactive map interface designs: a case study integrating usability metrics with eye-movement analysis[J]. Cartography and Geographic Information Science, 2009, 36(1): 5-17.

[6] Roth R E, Çöltekin A, Delazari L, et al. User studies in cartography: opportunities for empirical research on interactive maps and visualizations[J]. International Journal of Cartography, 2017, 3(sup1): 61-89.

[7] Kavouras M, Kokla M. A method for the formalization and integration of geographical categorizations[J]. International Journal of Geographical Information Science, 2002, 16(5): 439-453.

[8] Caquard S, Cartwright W. Narrative cartography: From mapping stories to the narrative of maps and mapping[J]. The Cartographic Journal, 2014, 51(2): 101-106.

[9] Caquard S. Cartography I: Mapping narrative cartography[J]. Progress in Human Geography, 2013, 37(1): 135-144.

[10] Cheliotis K, Liarokapis F, Kokla M, et al. A Classification of Augmented Reality Approaches for Spatial Data Visualization[C]//2021 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct). IEEE, 2021: 367-372.

[11] Çöltekin A, Lochhead I, Madden M, et al. Extended reality in spatial sciences: A review of research challenges and future directions[J]. ISPRS International Journal of Geo-Information, 2020, 9(7): 439.

[12] Caquard S, Fiset J P. How can we map stories? A cybercartographic application for narrative cartography[J]. Journal of Maps, 2014, 10(1): 18-25.

[13] Lombardo V, Damiano R. Storytelling on mobile devices for cultural heritage[J]. New Review of Hypermedia and Multimedia, 2012, 18(1-2): 11-35.

[14] Wang Yanyan, Wang Hao, Tang Xiaolan. Study on the Historical Significance Change and Modern Value Renewal of Nanjing Ming City Wall[J]. Chinese garden, 2014,30 (08): 89-91.

[15] Araoka W, Hokoi S, Ogura D, et al. Deterioration and preservation of City Wall in Nanjing[J]. Energy Procedia, 2017, 132: 945-950.

Acknowledgment