Dr. Claire Chenxi Qi

Weijia Zhu

Danni Zhou

Sitong Liu

Suyao Liu

Yang Liu

Class Manager, BA

CAA and NACAA

Dr Qi has sixteen years of experience managing international classes and workshops at CAA with German and French partners.

Since 2022, Dr Qi has been a lecturer and a researcher in media art practice, and history at NACAA; the ioint institute between l'École de design Nantes Atlantique (EDNA) and China Academy of Art (CAA) in Hangzhou, China. Currently, she is the contact person for CAA at Cumulus.

Dr Qi's VR documentaries won national awards in China. Her current research focuses on algorithmic art and media design.

East Sea Frontier: An Intermedia Design for the Guard Town Changguo Wei in East China

(Note:This paper is an extended version of the paper "Mapping the History: An Intermedia Design for A Coastal Town in East China", which was published in the conference proceeding of The Future of Heritage Science and Technologies ICT and Digital Heritage, Rocco Furferi, et al. eds, Springer, 2022.)

Abstract

Intermedia technologies are rapidly developing in preserving and presenting historical heritage. Intermedia technologies such as mapping, projection, motion capture, 3D modelling, information visualization, and interaction design expand the scenario of displaying hidden history. This article presents an intermedia design project of the East Sea Frontier as a potential entrepreneurship venture, commissioned by Xiangshan County for its cultural tourism in the coastal area of Zhejiang province, East China. Xiangshan County has a history of ancient coastal defense. Changguo Wei was a guard town in Xiangshan. The design aims to create a cultural identity of Changguo Wei with expressive intermedia narration and artistic language. First, we search historical documents and discover critical stories for representation. Secondly, we formulate the design concept and find the location to realize it. Then, we apply multiple technologies to visualize the historical content and build the interaction for an enhanced experience. The complete design consists of Light Matrix, Virtual Armor, Mapping Ancient Xiangshan County, and

Meta Space Tour of Changguo Wei. This project provides various ways to integrate entrepreneurship initiatives through design into cultural tourism.

Introduction

The coastal defense was an essential part of state defense in the Ming dynasty in China. The Southeast coastline of China has been under continuous attack by Japanese pirates since the 17th century. The royal court of the Ming Dynasty formed a defense system along the coastal line to protect the people and the land. The system consisted of guard towns (卫), battalions (所), and communication routes. Wei-Suo (卫所) was the system's basic unit. Zhejiang, Fujian, and Guangdong were the three main provinces that formed the military frontier against Japanese pirates in the southeast coastal area of China during that period. Each province had the same defense system operated with local geological features and cultural backgrounds. (1) Many official documents carefully recorded the defense system and the battles. Maps of prefectural cities, counties and guard towns were also included. In addition, there were paintings depicting Ming armies fighting with pirates considered as another kind of historical document.

Changguo Wei was a guard town in Xiangshan County in Zhejiang province during the Ming dynasty. The local government commissioned the project to promote its history as a cultural identity for tourism. With the aims of providing various ways to integrate historical heritage into cultural tourism with entrepreneurship strategies, our team forms the concept of the East Sea Frontier. It is an intermedia exhibition inspired by

historical documents consisting of four interactive installations. The Light Matrix installation demonstrates how the watchtowers transmitted the signals of upcoming battles during wartime. The Virtual Armor allows the tourists to virtually dress up in a suit of lamellar armor in Ming style. The Mapping Ancient Xiangshan County is a projection of a digitalized ancient map of the county in the Ming and Qing dynasty. Finally, the Meta Space Tour shows the local history, an interactive wheel map of Changguo Wei, and an interactive installation of a virtual navy battle. Each part allows tourists to experience an aspect of the coastal defense history of Changguo Wei. The design of the East Sea Frontier revives the historical scene of the invasion of the Ming army fighting against the Japanese invaders nearly six centuries ago.

This paper presents the academic research and the design methodologies in the project. The parts of the interaction design are realized in a laboratory circumstance. A short version of the paper was published as a conference paper in The Future of Heritage Science and Technologies ICT and Digital Heritage, Third International Conference, Florence Heri-Tech 2022.

Literature review

Academic research on the application of media technologies in cultural heritage preservation and representation focuses mainly on the technologies, design methodologies, technic implementations, and representation strategies. (2) Jeffrey T. Clark claimed that in cultural heritage, 'construction' should be a tool for understanding the subject rather than repeating the reality. (3) Practitioners like Jeffrey Shaw embraced the conjunction of technologies and cultural heritage. (4) Yet there are articles questioning the nature of the virtual reconstruction of

the cultural heritage. After sorting digital technics applied to cultural heritage, Liritzis and others pointed out there are adverse effects that cultural heritage is fragmental during the digital processes of 3D scanning, image digitization, information analysis, and virtual environmental reconstruction. 'Immersive feeling' overwhelms 'scientific knowledge.' (5) Forte wrote that incorrect digital reproduction of the subject would cause cognition loss rather than increase. He believed that cultural heritage, such as archaeological information, should be organized with correct context from cognitive aspects of the complexity of virtuality. (6)

Recent research shows a more positive attitude on this topic. The value of digital reproduction lies in interaction. (7) Transformation in such a design strategy implies that the viewer's experience becomes the centre of the design. Furthermore, cultural heritage is defined by their inextricable connection to society and people. Social development inevitably impacts the accumulation of knowledge of cultural heritage. (8) Cultural heritage evolves along with societal development. One phenomenon is that cultural heritage tourism has flourished significantly. Advanced technologies emerged and heated this market on a global scale as well. There is opportunity to initiate entrepreneurship venture that encourage the implementation of cultural heritage. Beyond theoretical analysis, the pursuit of economic growth excites many.

Case studies and methodology

Case studies

Two cases are analyzed to compare the methodologies and design concepts:

Namban Byōbu the Tenshō Boys Embassy

Many design projects transformed historical heritages into artworks. For example, the Namban Byōbu the Tenshō Boys Embassy (Nanban folding screen Tensho Mission to Europe), created by teamLab, was a video projection on the wall and designed to interact with a smartphone app. (9) The video depicted trade between the Japanese and Portuguese at the port of Nagasaki around the Azuchi-Momoyama period. People of various races, occupations, and historical figures walk around the scene. The scene changed along with the actual seasons. In 1582 four young boys traveled to Europe from Nagasaki to show the results of Christian missionary work in Japan to the Pope as "Tensho Missions to Europe." The work also combined this historical event with the trade scenario. The original folding screen's artistic quality and the Christian mission's storytelling were merged with the animation and the interactive experience. The work innovatively combined two stories into one context, interweaving time and space without losing the essence of the actual history.

Pure Land

Some works were more valuable for academic research or exhibition in a museum, such as the Pure Land project of Dunhuang Cave Paintings by Jeffrey Shaw. (10) It was a design of two visual systems showing the endangered Dunhuang cave paintings by augmented reality. The system integrated archeological data with an immersive visual display. Dunhuang was a gateway in northwest China more than a thousand years ago. It was a geographic cross-point on the Silk Road and a place for worshiping Buddhism. For a long time, monks and artisans

produced murals and sculptures of Buddha in the caves in Dunhuang. But the artworks were very vulnerable due to weather conditions and the heavy load of tourists. Pure Land is initiated to preserve this cultural treasure. The project recreated a virtual environment of the caves by embedding high-quality photographs of the mural paintings and laser scanning data into a 3D visualization system. Audience could see the stereoscopic images in a panoramic environment using head-mounted glasses or tablets. This design strategy comprehensively represented archeological information and provided the audience with an informative experience.

Methodology

This section briefly describes the software TouchDesigner applied in the project and the design strategy of the project.

TouchDesigner (TD) is an intermedia development platform developed by the Canadian company Derivative. It is widely used in real-time projects such as interactive media systems, 2D or 3D projections, music visuals, or rapid prototyping in artistic, educational, or commercial cases. TD's open platform offers multiple solutions to various projection scenarios. TD can communicate with LED lights. It converts many types of data to activate LED lights and allows flexible visual effects. It imports various visual or audio files, and exports enhanced intermedia displays. Connected with the Kinect toolkit or webcam, TD enables real-time geometry modelling or motion capture to control interactive installations.

The East Sea Frontier applies these functions to visualize the design concept. The first stage is a site survey and historical document research. We formulate the design concept for each

part based on the survey and research results. The second stage is to visualize the design concept utilizing visual elements from historical documents, physical materials, and simulation of the environment. Our design also implements intermedia design principles to prepare the visual part suitable for the interaction effect. The third stage is TD programming. Several tests improve the visual effect and upgrade the visual experience before drawing the result. (See Fig.1)

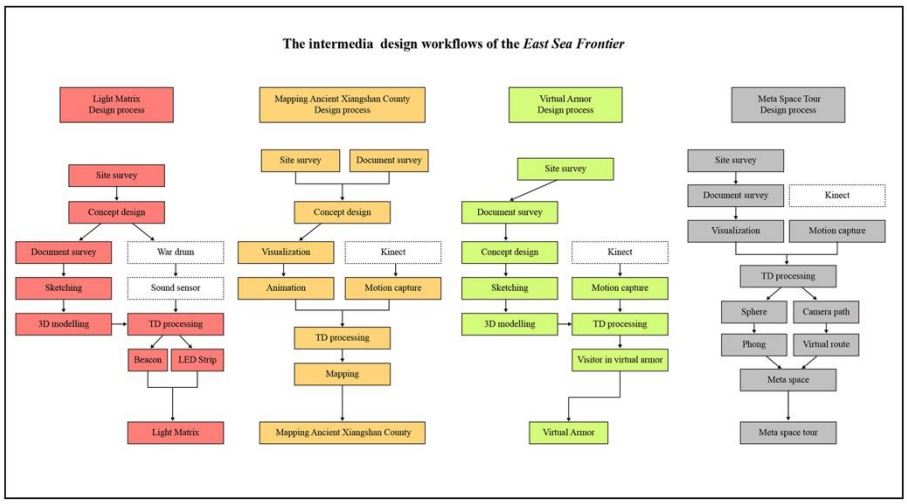


Fig.1. The intermedia design workflows of the East Sea Frontier

The history of Changguo Wei

Xiangshan County was established officially in 708 AD in the Tang dynasty, located on the east coast of Zhejiang province, east China. As one of the most important ports of Zhejiang, Xiangshan County was famous for trading and as a safeguard. Since the early Ming Dynasty, Japanese pirates invaded this area annually. Therefore, the Ming court built a coastal defense system to pacify the area. It was called "Five Guard towns and Nine Battalions" (五卫九所). Wei-Suo was an abbreviation of the system. It constructed guard towns and battalions and was supplemented by military facilities such as inspectors, beacons, and piers. Changguo Wei

was built as part of the system during this period. (11)

Overall, Changguo Wei consisted of one guard town and four independent battalions connected by courier route. The guard town covered an area of approximately 1.1 square kilometers with a maximum garrison of over 4800 troops. There were offices, arsenals, temples, and barracks inside, walls with watch towers, and training fields outside. (12) (Table.1). Initially, it functioned exclusively as a military fortress. Gradually the army became self-sufficient and increasingly involved in civic service due to the military farm system, like most of the garrisons did in the Ming regime. (13) The soldiers operated military farms around Wei-Suo part-time to provide their supplies. Once the pirates attacked, the farmers were recruited as soldiers.

Facility		Changguo Wei
Military Facilities	Command Centers	Dukun Office
	Other Military Facilities	Qidao Temple, Military office, Pharmacy, Lotus Pond, Training fields, Barracks
Civic Facilities		14 temples, 1 palace, 1 townhall

Table 1. The analysis of the urban plan of Changguo Wei in the Ming dynasty

There were several sorts of documents archiving this distinguished military history. Atlas of Coastal Defense (筹海图编), an authoritative coastal defense document, was edited by Zheng Ruozeng and Hu Zongxian in 1562. This document had two volumes: The first volume had text records of the military system of the southeast area of China. It also described geographical characteristics such as offshore areas, bays, tidal river-mouth,

mountains, ports, etc. The second volume included a study of Japan and detailed drawings of armour, weapons, and marine ships. (14) Local chronicles were another authentic resource of ancient maps. The map of Changguo Wei was shown in The Chronicle of Xiangshan County in the Daoguang period in the Qing dynasty. (See Fig.2)

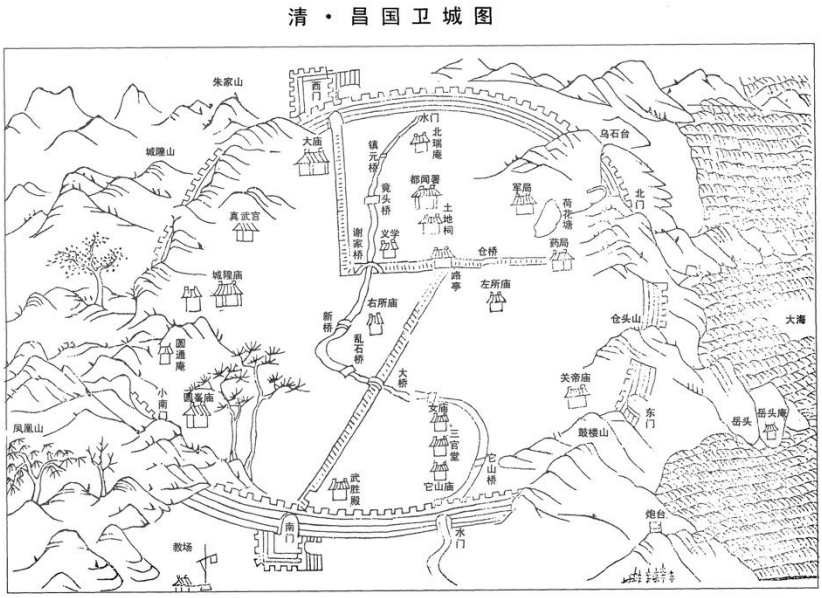


Fig. 2. The Map of Changguo Wei Guard town

Artistic paintings also depicted the history of sea battles against pirates. One was illustrated scroll Wako-Zukan（倭寇图卷）by Qiu Ying, probably produced in the early 17th century. (See Fig.3) It was a visual document for celebrating a victory over the pirates. (15) It came to Japan from China in the early 20th and is now in the Historiography Institute, Tokyo University archive. In 2010, an infrared analysis of the scroll was conducted by Historiography Institute, and researchers discovered some characters beneath a painted flag on one of the ships. It indicates that the scroll depicted a battle that possibly happened in 1558. (16) It depicted the story in four stages. The first stage was Japanese pirates invading by ships. The second stage was pirates looting and

burning a village. The next stage was Ming soldiers fighting against pirates on boats. The final stage was the Ming army marching from a guard town to the battlefield. It provided significant information and a visual supplement for our design.

Fig.3 Wako-Zukan

The East Frontier

Even though it was the birthplace of its history, only a few cultural monuments remain in Changguo Wei, and no other forms of displaying it. Moreover, due to the province's rapid urban development during the last 40 years, Changguo Wei faces a disequilibrium between economic demand and cultural inheritance. (17) Developing a cultural tourism economy is a common entrepreneurship solution in such circumstances.

A local theme park, an ideal location for the project, was constructed in 2021. It is part of a more prominent tourist zone by sea, Half Mountain resort, famous for its natural scenery. However, most visitors find the park lacking cultural attractions. People are no longer easily attracted by traditional sightseeing and only come here in summer. After the theme park opened, operating income was consistently low. To revive the site, cultural heritage tourism becomes a solution. Local government founded a company to execute the initiatives. Changguo Wei's original location is only a few kilometers from the theme park. Therefore, The East Sea Frontier is designed to be located in this theme park. The theme park has two sections (A&B). The whole project covers an area of approximately 3,000 square meters in the section A. (See Fig.4)

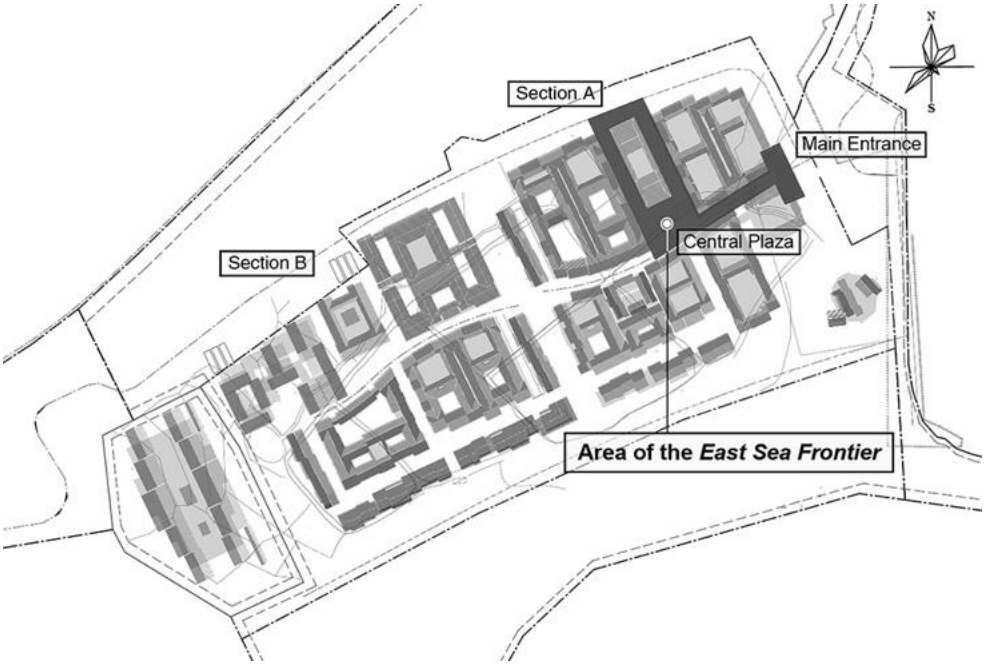


Fig.4. The master plan of the local theme park

The concept is to allow the tourists to enjoy an immersive exhibition with rich historical information and living narration. (See Fig.5) Four installations occupy different spaces in the park. First, the Light Matrix leads the visitors from the main entrance to a central plaza. Secondly, an enormous interactive animation of Mapping Ancient Xiangshan County is projected on a building's walls. Then, the Virtual Armor is installed on an opera stage, modeling armor in an antique style. Finally, an indoor intermedia exhibition of Changguo Wei, Meta Space Tour of Changguo Wei, is installed inside a building on the backside of the stage.

Fig.5. Simulation of the Mapping Ancient Xiangshan county

The Light Matrix

According to Sequel Research on Coastal Defense History in Zhejiang (两浙海防类考续编) and ancient maps documented in the Chronicle of Xiangshan County in Daoguang period in the Qing dynasty (清道光象山县志), there were beacon towers or watchtowers all along the coast of Xiangshan in the Ming and Qing dynasty. (18) (19) It was a communication system that could be put into operation rapidly. Soldiers lighted up fire or smoke to transmit signals when pirate ships were spotted. Five of these were constructed on hills in the Changguo Wei area. The main body of the beacon tower was usually built of bricks with a granite base; it was narrower on the top and broader at the bottom. (20)

The Light Matrix installation simulates the beacon towers both in form and function; it is designed to be installed between the entrance and the central plaza of the theme park. It has three parts, two war drums with sound sensors, two LED light strips installed along the path, and several beacon lights attached to the building walls. The LED strip is made of IP68-rated plastic and customized lightweight skeletonized aluminum. A 3000K temperature color light source produces a blaze effect. The configuration of the beacon light embodies the key features of the ancient beacon tower—a frustum cone-like hollow lamp with incandescent light. The shell is made of cast copper coloring in bronze. The name of each beacon light is projected on the wall through the hollowed-out sections symbolizing the original beacon tower.

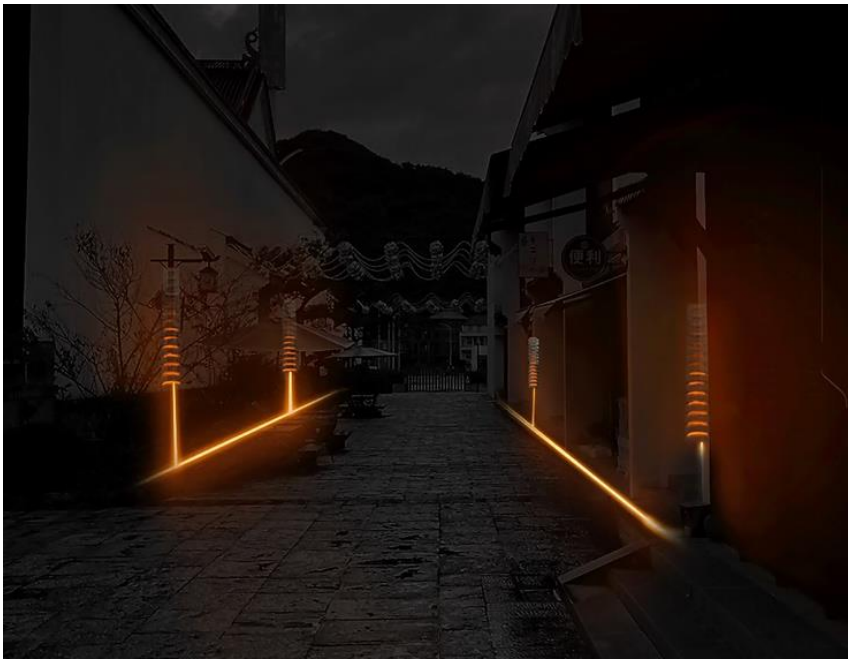


Fig. 6 Simulation of the light matrix installed in the theme park

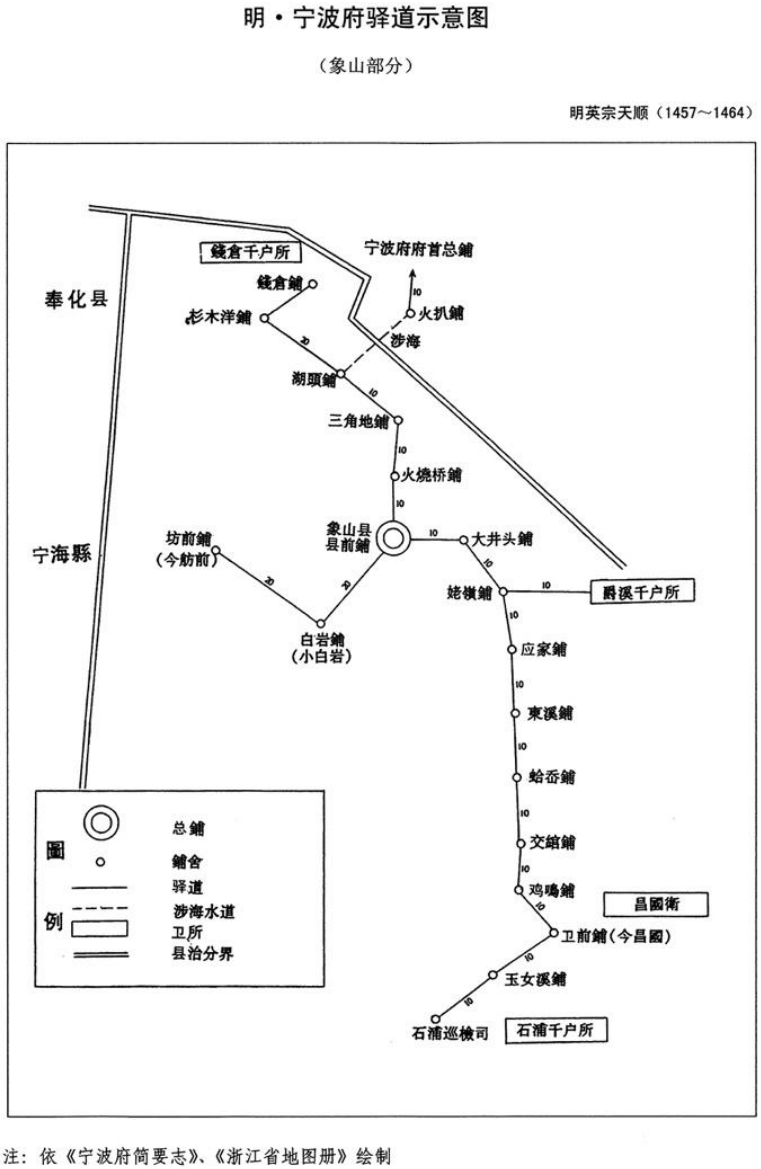
When visitors beat the war drums, the sound sensors capture the sound signals and trigger the light strips and the beacon by TD. The LED strips would create a flowing light imitating the signal transmission in ancient times when the flowing light reaches the beacon and turns it on. The faster the war drums are beaten, the brighter the 'blaze' becomes. Therefore, it corresponds to the signal-transmitting process and allows the visitors to immerse themselves in a battlefield atmosphere by imitating sending a war message. (See Fig.6)

Mapping Ancient Xiangshan County and Virtual Armor

The Light Matrix leads the visitors to the central plaza of the park. An interactive animation projection, the Mapping Ancient Xiangshan County, could be seen on the walls of a building on the plaza's south side, showing Xiangshan County and Changguo Wei in the Qing dynasty.

The design combines two historical maps. The first one is a colored map of Xiangshan County documented in The Atlas of Zhejiang (浙江全图), whose author remains anonymous. This precious manuscript is currently in the collection of Département des Manuscripts, Bibliothèque Nationale de France. (21) The complete set contains 88 maps of 11 counties in Zhejiang Province in the Qing Dynasty, including Xiangshan County. The map charts its geographical features and Changguo Wei's location on the coastline. (See Fig.7) The other one is a roadmap from A Brief Chronicle of Ningbo (宁波府简要志) and reprinted in the Military Chronicle of Xiangshan (象山军事志). (22) (See Fig.8) The map outlines the courier route from Xiangshan County to Changguo Wei, with each courier station inscribed.

Fig. 7. The digitized map of Xiangshan county in Mapping Ancient Xiangshan County



注：依《宁波府简要志》、《浙江省地图册》绘制

Fig. 8. The courier route map of Ningbo in the Ming dynasty

Additionally, the animation occupies specific ancient poems about Xiangshan to convey cultural richness. Eighteen poems written by local poets in the Ming and Qing dynasty are documented in the Chronicle of Changguo Wei (昌国卫志), describing the landscapes and coastal defense history. (23) We excerpt five poems and visualize the texts.

We implement the original map as the background layer and include additional visual elements, such as inhabitants, mountains, trees, poems, beacon towers, and the courier route. They are extracted, segmented into multiple layers, and added to the background layer. Our team also animates scenes such as fishers cleaning with nets, locals performing drama, smoke rising from the beacons, and soldiers training to shoot arrows. Images are reproduced in a similar style as Wako Zukan. Subsequently, the augmented map is projected on the walls. The dynamic effect of the projection visualizes manifold information about the history and provides an aesthetic experience. (See Fig. 9)

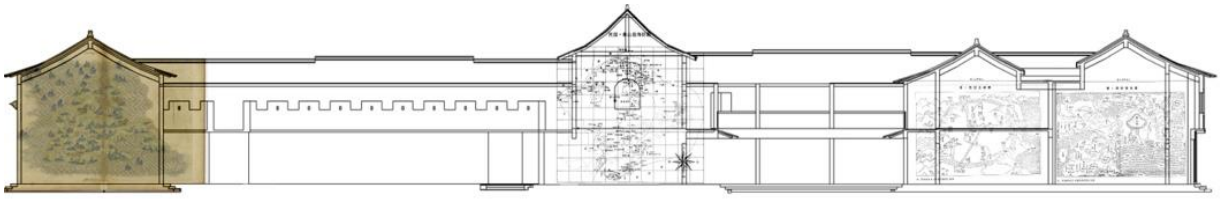


Fig. 9. Simulation of the projection on walls

After experiencing the digital map, the visitors could visit an opera stage across the plaza. The Virtual Armor is installed on the stage. It includes a display screen, a motion capture system, and TD as a backend processor. When a visitor's body movement is detected, the human figure is rendered by TD and appears wearing a lamellar armor suit on the screen.

In the Ming dynasty, lamellar armor for the navy was made of iron, calabash, or leather. (24) We render the virtual armor with an iron texture and apply a suit pattern for higher rank officers. Therefore, it dresses the visitor as a navy officer from six centuries ago. The virtual figures could interact with each other if several visitors were detected. (See Fig.10)

Fig.10. Simulation of Virtual Armor installation on the opera stage

Meta Space Tour of Changguo Wei and indoor exhibition

After experiencing the ancient map projection and the virtual armor, visitors could move to an essential exhibition section; it is an innovative interactive installation that conveys more comprehensive content and includes three sections:

- ***A chronological document exhibition***
- ***A compass wheel carved with the urban map of Changguo Wei***
- ***An immersive interaction installation of the Meta Space Tour of Changguo Wei (MST)***

The document exhibition consists of eight scrolls introducing Xiangshan County's history in the Yuan, Ming, Qing, modern, and contemporary periods. The compass wheel applies a concentric circle form and an extra translucent overlay of printed Qimen Dunjia (奇门遁甲). It is known as 'Strange Gates Escaping Techniques,' an arcade form of divination to form military tactics developed during the Warring States period in China. By rotating the compass, the urban map of Changguo Wei corresponds to Qimen Dunjia, indicating that it was devised for military tactics. (25) (See Fig.11)

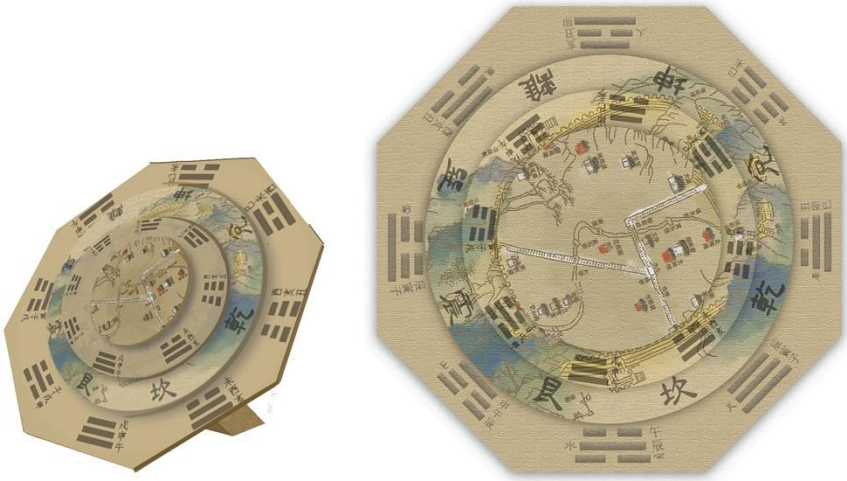


Fig. 11. Simulation of the compass wheel

The essential installation in this part is the MST. It is an intermedia representation of a battle against pirates. Physically it utilizes a large-scale LED screen and motion capture system. Walking toward the screen, visitors can see a virtual battlefield. The peninsula of Xiangshan County is morphed into a sphere—like a planet Xiangshan in a meta space. The sphere sits in the center of this space and rotates continuously. The map of Xiangshan county is applied on the sphere as Phong texture. The space, a metaphor for the battlefield, is scattered with numerous images--mountains, villages, natives, ships, pirates, and soldiers dashing forward to the viewers endlessly. It creates a tense battling effect. These images are extracted from the scroll Wako-Zukan. A virtual courier route is extracted from the route map and transformed as a linear path extending into the distancing space.

Likewise, MST uses motion capture technics to collect real-time data for the computing process. With the reflective marker technology, the viewer's body movement is followed by infrared light sources built into each camera. In a valid visual field of 3 to 5 square meters, the distance between viewers and the screen would be detected precisely at the millimeter level. The data of

the distance between the viewer and the LED screen maps the built-in camera motion trail and moving speed parameter. Therefore, the virtual route automatically stretches into deeper space when a viewer approaches and speeds up when the viewer moves closer. (See Fig.12)

Fig. 12. The visualization of the Meta Space Tour of Changguo Wei

Graphics in MST are superimposed on the specific frequency bands, so a variable speed effect on the y-axis can be achieved. MST includes approximately three hundred polygonal shapes and various texture data. After processing the data, TD broadcasts the data to the LED screen via the Virtual Reality Peripheral Network (VRPN) protocol via Ethernet. The LED screen is 6 meters long and 4 meters wide with a resolution of 3840 × 1088 pixels and a dot pitch of 3 millimeters. The screen has a black matte surface, corrugated light-absorbing masks, and an automatic brightness adjustment function. It enables the viewer to see clearly in bright environmental light.

Inspired by historical facts and conjunct with intermedia technologies, MST develops from a simple visual reconstruction to a multi-layered interactive narration. It interprets written documents into a symbolic scenario in virtuality. The design strategy is to break the timeline and geographic structure to create an imaginary space journey.

Conclusion

The East Sea Frontier project offers an immersive experience for visitors by combining historical heritage and intermedia technologies. Altogether, the Light Matrix, Virtual Armor, Mapping Ancient Xiangshan County, and Meta Space Tour of Changguo Wei express the richness of the history and intermedia aesthetics. The design concept creates a new narration with a nonlinear structure. Thanks to Touch Designer, motion capture technology, and multiple types of equipment, it is possible to develop an interactive system to visualize the design concept. It shows the advantage of technology as well as the liveliness of the historical heritage. Ancient history could adapt to contemporary intermedia design. Xiangshan county bears a crucial historical memory of the coastal defense of the East China Sea. Changguo Wei is the core figure in this memory. Utilizing ancient maps, paintings, poems, and other written records, the East Sea Frontier project creates a cultural identity that integrates a historical value. The Implementing interactive installations and immersive experience design expands the reconstruction of a piece of history in form and content. Ideally, the practice of the project would offer a positive solution to enhance the cultural tourism economy with proper entrepreneur strategies.

Abbreviation

TD*: Touch Designer; MST: Meta Space Tour of Changguo Wei; VRPN: Virtual Reality Peripheral Network.*

Declaration

Availability of data and materials

The data used and/or analyzed during the current study are available from the corresponding author.

Competition interests

The authors declare that they have no competing interests.

Funding

The authors declare that they receive no funding for this paper's research and authorship.

Authors' contributions

QCX: conceptualized the project, did field investigation, provided lab recourse, wrote the main body of the paper, and supervised team members' work. ZWJ visualized the Light Matrix installation and contributed the relevant part of the paper; ZDN, LST, LSY, and LY visualized the Mapping Ancient Xiangshan County and the Virtual Armor installations and contributed the relevant piece of the article. All authors developed the Meta Space Tour of Changguo Wei.

Acknowledgments

Prof. Jeffrey Shaw provided significant support to our research and design. The technical part of the East Sea Frontier was managed by Mr. Zhang Yifan and realized in Oasis Media Lab, Hangzhou, China.

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