

Cross-device system design based on stylized 3D map for intangible cultural heritage in Yunnan of China

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Yunnan Province boasts a rich cultural heritage, owing to its unique geographical location, topographical environment, and multi-ethnic background. However, existing digital preservation methods have limitations in presenting a large volume of information about Yunnan's intangible cultural heritage (ICH) to users in a visually appealing way. In response, this paper proposes a stylized 3D map-based approach that incorporates Yunnan's natural environment to display a substantial amount of ICH information, in order to improve user's interest and understanding of ICH. In addition, to cover more application scenarios and improve the communication effect, this paper designs a Crossdevice Display System (CDS) that integrates mobile, PC, and VR terminals to present the 3D stylized maps, and users can interact with 3D map on different terminals to obtain ICH information.

Keywords: *intangible cultural heritage; culture experience; cross-device design; virtual reality*

1 Introduction

Yunnan is the province with the largest ethnic minorities in China and has a rich cultural heritage of ethnic minorities. Its unique geographical location and topographical environment have together nurtured a large number and wide variety of ICH resources (Yang, 2015; Xiang et al, 2021), three of which are listed in the Representative List of Intangible Cultural Heritage of Humanity¹ (127 are listed in China's national intangible cultural heritage programs).

Due to the "living" and "intangible" nature of ICH, its dissemination and preservation have been extremely challenging (Huang, 2015). At present, some methods such as resource databases and websites are only direct descriptions of ICH content through text, images, and videos, which are

¹ <https://ich.unesco.org/en/lists>



limited to the expressiveness and interaction of 2D planes and cannot allow people to feel and participate intuitively. This is an obvious limitation for the dissemination of the considerable amount of Yunnan ICH information. Especially for young people, who are the main audience of ICH dissemination, the traditional methods are not attractive enough. In recent years, digital virtual museums, XR experiences (Yu et al, 2021; Liu et al, 2022) and other digital communication vehicles (Liu & Yan, 2022) have emerged for ICH. However, most of them are only for one or a particular type of ICH. To address this issue, this paper proposes a more participatory and artistic display of ICH to enhance people's acquisition and understanding of a large amount of ICH information, thereby improving the effectiveness of dissemination.

For Yunnan ICH, this paper found in research that the formation and distribution of Yunnan ICH are closely related to the geographical conditions of Yunnan. Inspired by the design method of geographic information visualization, this paper visualizes and presents Yunnan ICH information on a 3D map. A stylized 3D map of Yunnan was designed by combining the geographical environment landscape of Yunnan with the representative attractions, architecture, and products of each state and city in Yunnan to enhance the fun and artistry of the map. The 3D map provides an immersive scene of the natural environment of Yunnan, which can make people feel the ICH in the context and understand more effectively through interaction (Marcus et al, 2003).

3D map-based information visualization is well-suited for presentation in an immersive environment. In recent years, VR has gained much attention in the digital protection of ICH (Vosinakis et al, 2018). The immersion and multi-sensory interactive experience of VR are efficient for presenting ICH information (Liu et al, 2022; Zou et al, 2022). However, VR is still dependent on the device and the experience environment, and the mobility, popularity and dissemination are far less than that of mobile devices (Yuan et al, 2022). This paper proposes a Cross-device Display System (CDS) for Yunnan's ICH that integrates mobile, PC, and VR. The system can fully use the immersion and interactivity of VR but also consider the popularity of mobile devices to cover more application scenarios, realize the connection and integration of multiple types of information, and thus enhance the communication effect of ICH. This paper adopts the concept of responsive design to fully consider the consistent design of each device (Santosa et al, 2013) but also to reflect the design differences according to the characteristics of different devices.

The rest part of this paper is organized as follows. Section 2 is the literature review, including the digital technology protection of ICH, the research background of 3D information visualization, and an introduction to the concepts and advantages of cross-device design. In section 3, the methodology of stylized 3D Map-based information visualization design is presented. In section 4, this article describes the experience on different devices, including PC, mobile, and VR. Finally, the conclusions and future work are presented in section 5.

2 Literature review

2.1 Digital technology protection of Yunnan ICH

The transmission and protection of ICH has always been a challenging issue. The database and website of Yunnan ICH for the public are established in 2007. XR technology can bring more immersive 3D information visualization, such as establishing virtual museums and visually reproducing ICH contents

(Doulamis et al, 2017; Windhager et al, 2018). Zixiao Liu (2022) et al. proposed "Dance of Drums", which reproduces the copper drum performance of the Yi and Zhuang ethnic groups in Yunnan through VR technology. The stylized artistic 3D environment, creative and rich dance movements and asymmetric interactive experience can enhance the attraction of young people to ICH. However, existing XR experiences for Yunnan are based on the display of one or several ICHs, lacking a digital display system covering the province's ICH.

2.2 3D map information visualization

3D maps can be used for more than just navigation tools and have been expanded to many more uses (Kjellin et al. 2008) Compared to all 2D map visualization approaches, the combined 2D+3D map (Ardissono et al, 2018; Le Malecot et al, 2006) visualization design approach is more efficient for conveying information and data.

The display of 3D maps in VR and MR to simulate geographic environments has been successfully applied in geography, architecture, and archaeology recently. METEOVIS (Li et al,2020) is a system that supports the simultaneous visualization of Spatiotemporal weather data from multiple sources and reduces the meteorologist's information analysis through 3D map visualization in VR cognitive load. Its stylized approach to model design provides this paper with a reference. The MR experience of London City Skyline reduces the complexity of the map (Ardissono et al, 2018). It mainly presents information about landscape architecture that is more important to the experience presenting a clean visual style Combining a 3D city model with 2D floating tabs to display architectural information about London, this design approach allows the public to access information quickly. It inspired the visualization of ICH information in this system.

2.3 Cross-device design

With the popularity and development of mobile and wearable devices, people's daily interactions with information technology increasingly involve more than one device (Dearman et al, 2008), gradually forming a multi-device ecosystem. Research on cross-device experiences continues to be produced by scholars (Brudy et al, 2019). A study identified the roles assumed by different devices in the environment (Santosa et al, 2013). Supporting multiple device experiences facilitates the dissemination of information (Yuan et al, 2022).

3 Stylized 3D map-based information visualization design

After the preliminary combing of literature and fieldwork, this paper interviewed 5 experts from the ICH Protection Center in Yunnan. The interview began with the experts sharing with designers their daily work on ICH, current limitations, and their practices in conducting ICH dissemination and understanding, as well as their expectations for this system. Experts also emphasized that the design of map visualization is important to enhance the understanding of ICH. Yunnan's ICH has distinct ethnic characteristics (with 26 ethnic groups), outstanding geographical features (complex topographical and geographical conditions), and various ethnic groups with inclusive and affectionate values (e.g., reverence for nature). In addition to this, experts expressed the hope that the system for displaying ICH would be eye-catching, as beauty, after all, inspires people to learn and spread the word.

Based on the previous research, this paper proposes a design framework that combines the information culture context of ICH with stylized 3D map-based visualization. According to the preliminary research and interviews, designers conduct a design study and propose a design method.

At the same time, the "Ten Classifications" and "Ethnic Classification" are adopted as the classification of the system.

3.1 Stylized 3D map design

The design work of the 3D map, this paper started with a satellite map of Yunnan to understand its actual appearance. In terms of readability and ease of learning about maps, early research (Allen et al, 2006) noted that "individual differences in the ability to learn from simple maps, figures, and diagrams are a product of both domain-specific knowledge and general visual spatial abilities". Realistic maps may interfere with access to ICH information and place an excessive cognitive load on users. Therefore, this paper designs a stylized 3D map artistically based on the information from the accurate map and reduces the complexity of the map space.

First, this paper collected essential information about 16 cities in Yunnan, including the highest/lowest elevation, average elevation and average elevation coefficient, major local topographical features (e.g., features such as snow-capped mountains, red land, forests), types of local ethnic groups that have lived there for generations, representative local architecture (e.g., characteristic local minority dwellings, pagodas and temples), local animals and plants (e.g., creatures such as Xishuangbanna Asian elephants, Wenshan meridians,), and the flow direction of the major 5 rivers that run through Yunnan Province and the two major lakes (Dianchi and Erhai). Based on this, this paper designs and models the base of the map (figure 1).

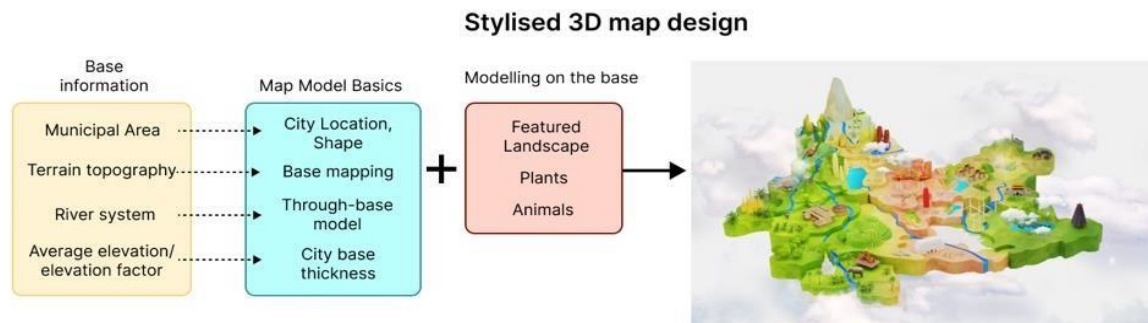


Figure 1. The processing and visualization of Yunnan map information.

In the map base, this paper grades the height above the mean sea level data of each city and give it an altitude coefficient (for example, 1 to 10). Afterwards, this paper incorporates the base with water resource information (such as rivers and lakes) and necessary terrain and geomorphological information (such as protruding snow-capped mountains and sunken valleys). To avoid excessive information pressure on users due to map visualization, this paper presented in a magnified and surreal artistic style. This not only enhances the fun and artistry of the map but also enables the public to understand the main features of the map clearly and quickly. Finally, designers use Blender, a 3D modelling software, to model the stylized 3D map.

3.2 Information preparation

As shown in Figure 2a, this paper completes the collection, screening, classification, and statistics of ICH information (Windhager et al, 2018). Information on the ICH project includes but is not limited to name, numerical number, image and text introduction, application area, city, and ethnic group. In the collection process, designers found that the same ICH item may belong to two or even more ethnic groups because of the inclusive and affinity characteristics. The same ICH item may involve two or even five application regions because the ICH characteristics of each application region are different. In general, the national-level ICH projects involve 20 ethnic minorities, the national-level ICH bearers involve 21 ethnic minorities, and the 127 ICH projects involve 140 application sites and 125 inheritors.

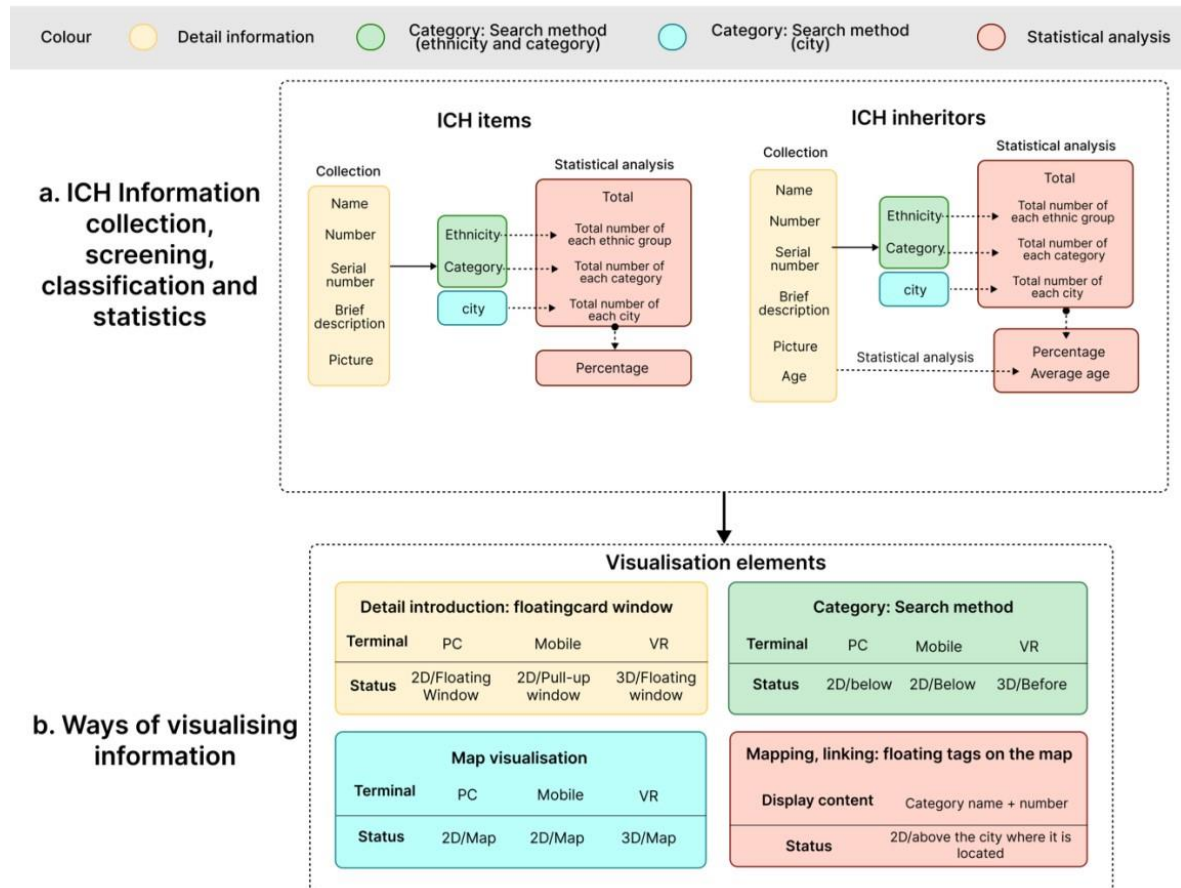


Figure 2. Statistics and classification of ICH Information.

3.3 Visual mapping of ICH information and map

The linkage interaction design between 2D information and the 3D Yunnan model enhances the efficiency of presenting information (Ardissono et al, 2018; Le Malecot et al, 2006). Therefore, this paper combines different kinds of information with 2D/3D visualization presentation according to the characteristics of information and the advantages of different devices (Figure 2b), thus integrating, mapping, and linking with the 3D map. Through interviews with experts, the search method based on ten categories and ethnic groups helps to create a more organized and clearer ICH information display. Therefore, this paper uses the ethnicity and type of ICH information as the retrieval method to interact with the map, and the visualization of the detailed ICH information (including information such as name, number, and serial number) is completed with a floating card window. This study closely

connects regional ICH information with 3D map visualization, and the data obtained after prestatistical analysis can be mapped with the floating card window by pop-up floating tabs in the corresponding region on the map.

4 Cross-device experience design

In this section, this paper proposes a cross-device system design paradigm (figure 3a). This paper expects cross-device design to increase user engagement, diversity, and integrity.



Figure 3. Diagram of Cross-device system(a), "About Yunnan" PC(b), Enlarged map(c).

4.1 PC and mobile experience

The PC and mobile experience are divided into two parts, namely "About Yunnan" and "About ICH". The "About Yunnan" page presents information about the 16 prefectural-level administrative regions of Yunnan Province and a summary of the projects and inheritors in each region. The 16 prefecturallevel administrative regions are categorized at the bottom of the page. The "About ICH" page visualizes the information on "ICH projects" and "ICH inheritors", grouped into "Ten Categories" and "Ethnic Categories", respectively.

On mobile and PC, users can freely explore the 3D map. The detailed information of the "2D floating window" and the map view will change accordingly when the user selects the "ethnicity" or "category". In order to help users understand the information more specifically, this paper combines the "floating tabs" of the 2D information with the 3D map. The floating tabs on the map and the content of the 2D floating window echo each other. In the interaction with the map model, the user can zoom, move,

and rotate the view of the 3D model. In this way, the user can zoom in (Figure 3b) to see the details of the map and zoom out (Figure 3c) to view a macro-overview of the map.

The system also supports a categorized search of ICH information. The map view and the content of the 2D information floating window will change accordingly when the user selects the "ethnicity" or "category". To help users understand the information more specifically. The information complements each other to form a complete information display. Visually, this paper used a clean and neat white background and black non-serif font to present precise information and aesthetic effects. This paper also adjusted the opacity of the 2D floating label text content and background color to 70% to make it more harmonious with the 3D map containing complex information (Figure 3c).

4.2 VR experience

In comparison to mobile and PC experiences, the VR experience features distinct spatial dimensions, display effects, and interaction methods. In VR system experiences, designers categorize the perspectives of experience design into two perspectives: the 'macro-perspective' (Figure 4a-b) and the 'micro-perspective' (Figure 4c-d), based on the design principle that "one perspective is not enough" (Windhager et al, 2018).

In the macro view, users can gain a comprehensive overview of the ICH information in Yunnan Province. Additionally, to maintain the consistency of the screen (PC and mobile) experience, the overall visual style of the VR experience remains consistent with the screen. It is also interactively mapped and linked with floating tabs and floating card windows on the map.

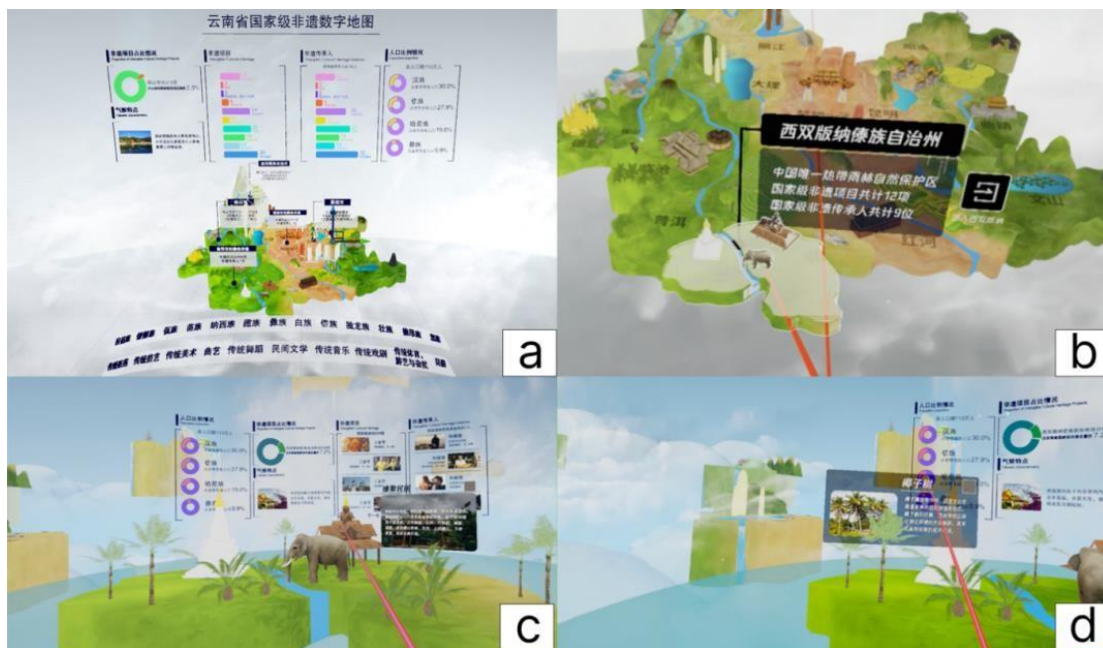


Figure 4. The experience of VR environment. macro view(a), click the macro view's tab on the map, enter the micro view(b), micro view of Xishuangbanna(c), and click on the coconut tree to show the introduction(d).

Figure 4a shows the initial experience space, the macro view. Using the vast design space of VR, in addition to displaying the content on the screen, it will additionally show the climate characteristics of 16 cities and the proportion of the city's native ethnic population. Combined with the visual experience characteristics in the VR environment, this paper design a responsive layout for the

category bar of information retrieval on the page, the angle and ratio of the initial map display, and the information layout in the floating tabs and windows.

This paper hopes to fully immerse the user in the stylized 3D map through the microscopic perspective of VR (Vosinakis et al, 2018). To better understand the preferences and suggestions of young people aged 18-28 in Xishuangbanna, Yunnan Province, for the microscopic VR experience of the city, designers conducted a small sample questionnaire survey. Out of the total 51 responses, 49 are considered valid. Over 80% of respondents are interested in information on local residential houses and iconic landscapes, while more than 60% of users expressed a desire to learn about local plants and animals, including the Asian elephant. They are also interested in a brief introduction to the city's features, non-traditional projects, and inheritors, as well as geographic information such as river topography. The findings from the user study guide this paper's design to the presentation of information for the microscopic VR experience of the city.

Users can enter each city in Yunnan (Figure 4b), which appears as an island floating in the blue sky. For instance (Figure 4c), users are allowed to walk around and observe the three-dimensional visual elements of Xishuangbanna, including elephants and Dai houses, based on the preliminary questionnaire research. These elements are not static, as users can move around them freely using the handle and interact with the 3D visual elements of the landscape on the map by pulling the trigger. By clicking on the 3D model of coconut trees with the handle, users can access detailed information about the coconut trees in Xishuangbanna (Figure 4d). This enhances users' understanding of Xishuangbanna's customs and geography, allowing them to experience and understand the ICH in an immersive manner.

5 Conclusion

This study proposes a design framework called Cross-device 3D Map-based Display System for ICH. Using Yunnan Province in China as an example, this paper presents an experience design that integrates mobile, PC, and VR based on a stylized 3D map. The framework selects different visualization methods based on the characteristics of various types of ICH information. The interactive 3D map experience aims to promote young people's understanding of Yunnan's ICH and to utilize the three terminals to reach wider users and enhance the dissemination of ICH. CDS has broad applicability to many ICH information groups with regional aggregation characteristics.

This study is ongoing, and the usability of the framework and prototype will be evaluated and validated. Additionally, user feedback will be used to analyze and refine the interaction of the system and the presentation of the 3DUI in the VR experience. In the future, this paper will investigate the interactive interface design for presenting ICH information in a VR environment, providing a more immersive VR ICH browsing experience. Furthermore, this paper will strive to enhance the cross-device design framework to optimize the system's continuous interaction experience.

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