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Mining and Visualization of Tourism Cultural Image Based on the Information Transmission Model of Tourism Cultural Map—Taking Nanjing Xuanwu Lake Tourist Attraction as an Example

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Abstract: Tourism cultural image is vital for conveying the cultural essence of a destination, enhancing tourists' cultural understanding and engagement. However, traditional tourism cultural maps often face challenges in clearly defining cultural themes and effectively communicating cultural and emotional information to users. To address these issues, we propose an improved information transmission model for a tourism cultural map to optimize the communication pathway between cartographers and map users. Based on this model, we introduce a method for mining and visualizing tourism cultural image using tourist attractions as the focal points. Then, based on the visualization results, we discuss the selection of map expression objects and the framework of map visualization design. Finally, we give an implementation process of a tourism cultural map of tourist attractions based on mining and visualization of tourism cultural image. To verify the method's feasibility, we developed a mobile interactive tourism cultural map application using Xuanwu Lake in Nanjing, China, as an example. The results demonstrate the method's effectiveness in tourism cultural image mining and visualization, provide solutions to the problems of traditional tourism cultural maps, and help tourists' understanding of the culture of tourist attractions.

Keywords: tourism cultural image; tourism cultural map; mining and visualization; social media data; Xuanwu Lake

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1. Introduction

Culture plays a crucial role in the tourism industry, transforming simple sightseeing into a profound understanding of history, art, and local traditions. It is a key factor in shaping tourists' experiences and cultural perceptions [1]. Tangible and intangible cultural elements offer different forms of storytelling, distinguishing one destination from another and creating an immersive tourism experience [2]. The richness of a destination's culture often becomes the essence of its identity, attracting visitors seeking to immerse themselves in unique cultural experiences [3]. Therefore, it is essential to improve tourists' understanding of the culture of their destination through effective tourism marketing strategies. This will help promote the value of the local culture and encourage tourists to engage more actively in their experiences.

As an essential tool for presenting tourism information, the tourism cultural map plays an active role in preserving and promoting tourist destinations' regional culture and fostering a deeper understanding of cultural heritage [4–7]. In recent years, digital technology has amplified the impact of tourism cultural maps, particularly integrating digital technology with cultural maps, which has become a powerful tool for showcasing

a destination's cultural landscape [8,9]. These maps depict cultural assets' geographic and spatial information and provide tourists with a dynamic and interactive platform. However, the application of tourism cultural maps often shows homogeneity in selecting representation objects, focusing primarily on three-dimensional visualizations of cultural landmarks [10,11]. Matlovičová et al. emphasized that natural and cultural heritage should be viewed as a dynamic process involving reinterpretation of past objects, events, and practices [12]. This perspective is crucial for designing tourism cultural maps. Relying solely on fixed cultural expression objects cannot adequately capture a tourist destination's deep cultural meanings and contemporary needs. The data sources and results of this selection process should be dynamic. Tourism cultural images include a wide range of cultural elements, such as historical landmarks, local traditions, and art forms, all of which deserve more comprehensive visualization to enable tourists to fully perceive a destination's cultural essence. At the same time, as "heritage thinking" evolves from a "preservation paradigm" to "the cultural and natural heritage paradigm," the emphasis on protecting natural and cultural heritage has shifted from valuing their "intrinsic worth" to prioritizing their ability to "serve contemporary purposes" [13]. Consequently, when selecting expression objects for tourism cultural maps, it is essential to consider their appeal and cultural significance to tourists.

Tourism cultural image represents a set of tourists' perceptions about a destination's culture. It reflects the history, art, traditions, and social background that tourists experience. It combines "intrinsic value" and "contemporary purposes", making it a valuable resource for selecting cultural expressions in tourist destinations. Currently, research on the mining and visualization of tourism cultural images is relatively limited and focuses primarily on two aspects: (1) mining and perception of cultural images based on text and image carriers related to tourist destinations, with the visualization of the spatial or spatiotemporal characteristics of these images [14,15]; (2) semantic analysis of tourism cultural images and visualization of the network relationships between cultural image elements, thereby exploring the cultural connotations of the destination [16]. While these studies have made progress in extracting and visualizing tourism cultural images, research on the downstream applications of mined cultural images and their integration with map design remains scarce.

Therefore, we take the Nanjing Xuanwu Lake tourist attraction in China as a case study with the following objectives: first, to construct an information transmission model of the tourism cultural map to clarify the process of communication between map creators, map users, and tourism cultural information; second, to propose a feasible method for mining tourism cultural images and selecting map representation objects for scenic areas; third, to present a visualization design plan for scenic area cultural maps based on cultural experience theory; and finally, to provide a feasible framework for the mining and visualization of tourism cultural images based on the information transmission model of the tourism cultural map. This aims to offer a reference for presenting regional cultural essence and promoting cultural dissemination through tourism cultural maps.

The rest of this paper is organized as follows: Section 2 provides a literature review of tourism cultural image and tourism cultural map of tourist attractions; Section 3 outlines the methodology of this study and the details of the method; Section 4 applies the methodology to the experiment of the Xuanwu Lake tourism attraction, including the introduction of the experimental area, dataset, main steps, and the final Xuanwu Lake tourism cultural map; Section 5 discusses and compares the research methods and results of this study; Section 6 presents conclusions and prospects future work.

2. Related Works

2.1. Tourism Cultural Image

Tourism image is the perception of a tourist destination, representing a comprehensive mental concept consisting of all subjective cognitions, impressions, and sentiments held by tourists [17,18], a series of attributes, feelings, and expectations related to the destination as

perceived by individual tourists, which is subjective and dynamic and combines cognitive and emotional characteristics [19]. From the perspective of tourism image generation, it is generally believed that tourism images can be divided into projected images and perceived images, in which projected images are the tourism images that tourism marketing organizations try to guide tourists to form. Perceived image is the image that tourists create in their minds. For the division of its conceptual structure, most scholars believe that tourism image has a multidimensional structure [20]. Johann et al. believe that tourism image has a two-dimensional structure of cognitive and affective [21]; Kun et al. propose the center-periphery structure of tourism image [22]; and Asli D.A. Tasci et al. believe that tourism image has cognitive, affective, and behavioral dimensions, and disassembled tourism image into three fundamental dimensions: cognitive image, affective image, and the overall image that the two together constitute [23]. The mental component is the sum of tourists' knowledge reserves about the destination and the knowledge about the destination that has not yet been acquired; the affective component is the tourists' feelings about the destination, i.e., their emotional reflections and evaluations of the destination, and the overall image is the tourists' comprehensive perception of the destination [24,25].

However, Gallarza et al. showed that tourism image contains almost all aspects of the destination and is less targeted to the perception of scenic culture [26]. Tourism cultural image, derived from this foundation, improves this. The concept of tourism cultural image consists of three main aspects, i.e., tourist destination, culture, and image, with the subject of the idea being the tourist destination, the object being the image, and the qualification of the object being culture. It is a comprehensive mental conception formed by cultural impressions, cognitions, and emotions generated towards a tourist destination, including the perception of material and spiritual culture [27,28]. In this study, we believe that tourism cultural image is the cognition and emotional experience of tourism destination culture formed by the interaction between tourists and cultural tourism objects as well as the tourism official publicity guide system, in which the cultural tourism objects are the holistic tourism cultural experience system based on the symbols of cultural tourism objects in the destination and the cultural space, which can be understood as the scenic spots in this study; the tourism official publicity guide system is a system that guides the tourists based on words, pictures, etc., guiding tourists to produce cognition and emotional associations of cultural tourism objects.

The study of the perception of cultural image in tourism has gained attention, and a range of approaches have been developed, including structured, unstructured, and mixed methods. Structured methods use questionnaires to design scales to perceive the cultural image of scenic spots in terms of infrastructure and tourism resources [29]. Unstructured methods capture subjective tourism cultural images by designing open-ended questions [17]. In recent years, the research of unstructured methods has shifted to Internet or self-media data, such as text and pictures, to perceive tourism cultural images of scenic spots through textual and visual analysis, which reduces the intervention of human subjective factors and makes the detection of tourism cultural image more objective. On the other hand, the hybrid method combines the two methods, combining scales and statistical methods of data to infer the tourism cultural image of scenic spots [30].

2.2. Tourism Cultural Map of Tourist Attractions

Cultural maps are designed to express cultural phenomena and humanistic feelings, depict the distribution of cultural elements in a region or society, and assist people in understanding a specific cultural space by visualizing the geographic location, interrelationships, and development process of cultural elements to play an active role in inheriting and disseminating regional culture and promoting sustainable cultural development [31,32]. The academic discussion on cultural maps focuses on the design [33,34] and the application of map compilation [35]. As for the application in scenic areas, there have been a few studies that have made attempts. Mülazimoğlu et al. explored the preparation of user-centered study scenic tourism cultural maps [36]; Zhou et al. provided a design method

for urban scenic tourism cultural maps by establishing a cultural genealogy [5]; Li took the folk culture of an ancient city scenic spot as an example and designed and realized the tourism culture map of that ancient city scenic spot [37]. These maps are primarily presented as tourist maps, often with the distribution of attractions in the scenic spots resulting from the expression. The selection of map expression objects has the phenomenon of homogenization, and it is not easy to reflect the cultural connotation of the scenic spots. Meanwhile, in integrated media, the map expression breaks through the physical space limitations [38]. The expression content, techniques, and interactive means also present a diversified development, and the current scenic area cultural map also lacks this aspect of attention.

2.3. Research Gaps

The existing research on tourism cultural image and cultural maps has provided a solid foundation for understanding the complex interplay between culture and tourism. Scholars have widely explored the multidimensional structure of tourism images, identifying cognitive, affective, and behavioral dimensions. However, there are still specific research gaps:

(1) Current studies often focus on general tourism images or overlook the detailed cultural nuances that could provide a more profound and immersive tourism experience. Moreover, although various methods, including structured, unstructured, and hybrid approaches, have been employed to study tourism cultural images, no such research has been reported on how to visualize tourism cultural image and extract the cultural connotations of tourist attractions based on the visualization results.

(2) While some attempts have been made to create tourism cultural maps, these efforts often suffer from homogenization in selecting expression objects, making it challenging to convey the cultural significance of the locations sincerely. The development of such maps in integrated media that transcend physical space has not been fully explored. Therefore, further research is needed to develop innovative methods for creating and visualizing tourism cultural maps.

3. Methodology

3.1. Study Area

Xuanwu Lake is located in Xuanwu District, Nanjing City, Jiangsu Province, northeast of the inner city wall, at the foot of Zhongshan Mountain; it is a tectonic lake formed during the Yanshan orogenic movement with a history of approximately 1 million years; it is a national 4A level tourist attraction [39]. The total area of the scenic spot is 5.13 km^2, and the lake surface area reaches 3.78 km^2. Xuanwu Lake is a historical and cultural lake with spiritual and beautiful scenery south of the Yangtze River, heavy historical heritage, and distinctive cultural characteristics. Its human history can be traced back to the pre-Qin period, the Six Dynasties period for the royal garden lake, the Ming Dynasty for the preservation of the yellow book of the National Archives, known as the "Pearl of the Jinling" in Nanjing thousands of years of cultural lineage of the nourishment, exudes a unique culture and charm (Figure 1).

3.2. Information Transmission in Tourism Cultural Map

3.2.1. Map Information Transmission Model and Its Application

The model of map information transmission reveals the relationship between map production and map use and how maps effectively convey information. Koláčný proposed the model to construct how mapmakers transform realistic observations into cartographic details [40]. With the development of cartography and the application of new media technologies, the theory of map information transmission has also attracted further thinking by scholars [41,42]. These models have enriched the map information transmission theory to different degrees. Still, the map information transmission model of scenic spot culture in the interactive mobile environment is not yet visible.

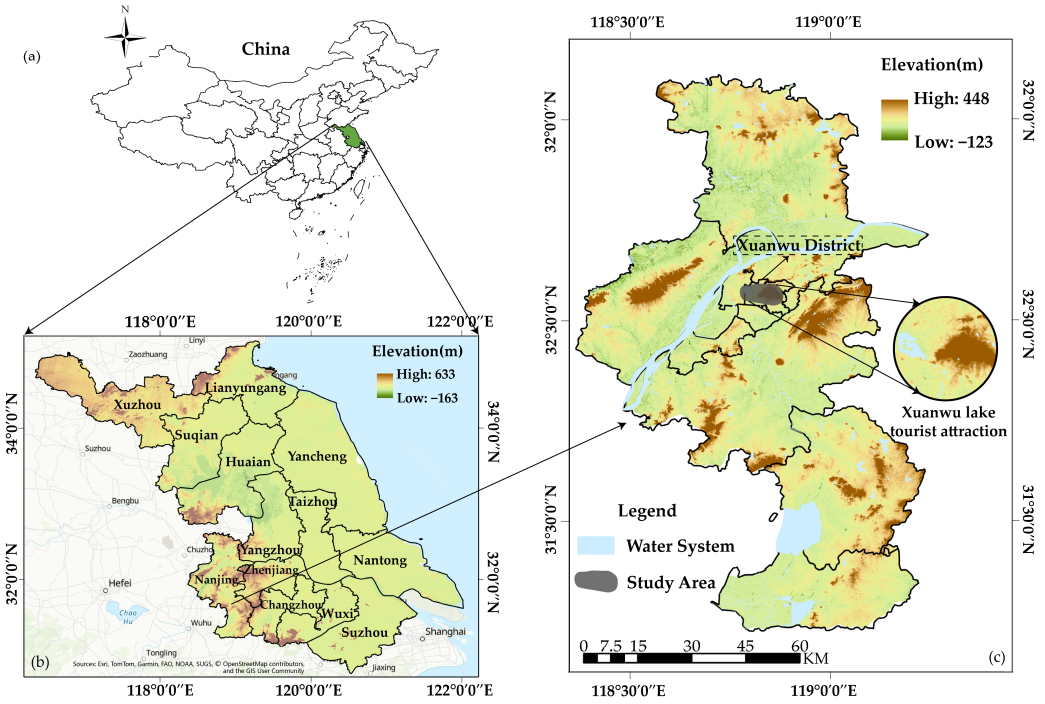


Figure 1. Location of Xuanwu Lake tourist attraction: (**a**) the location of Jiangsu province in China; (**b**) the location of Nanjing in Jiangsu Province; (**c**) the location of Xuanwu Lake tourist attraction in Nanjing.

3.2.2. Information Transmission Model of Tourism Cultural Map

Under the background of pan-map [43], the information transmission medium and process of tourism and cultural maps have changed from the unidirectional transmission mode of "cartographer-map-user" of traditional two-dimensional maps to the bi-directional or even multi-directional transmission mode of "cartographer-map-user-cartographer" of emerging media maps. The multi-directional transmission mode of emerging media maps has changed to the two-way or multi-directional transmission mode of "cartographer-map-user-cartographer", resulting in richer information transmission carriers and interaction means. Under this transmission mode, the interaction and feedback between cartographers and users become more convenient. Based on the above premise, this study proposes an improved information transmission model for tourism and cultural maps.

The information transmission model of the tourism culture map (Figure 2) mainly includes the following processes:

(a) Mining and analysis: The process begins with the cartographer (1) mining and perceiving the tourism cultural image, a crucial starting point for creating the map.
(b) Visualization and theme refining: Following this, the cartographer (2) concentrates on the cultural image, refining and focusing it on more specific themes.
(c) Selection of expression objects: The next step involves selecting expression objects (3) representing these themes on the tourism cultural map.
(d) Cognition and map visualization: The expression objects are then (4) cognitively understood by the cartographer, leading to (5) the visualization of these objects on the map. The map is then interacted with by map users who (7) experience the tourism culture and (8) perceive and understand the cultural connotations on the map. This completes the initial cycle where (9) the cultural cognition is gathered from users' interactions with the map.
(e) Feedback and Update Process: Based on the cultural cognition feedback (10) provided by the users, the cartographer (11) updates the processes (4–9), incorporating user insights into the artistic themes and their visualization on the map. The updated map is then (12) reviewed again for its tourism culture themes, and the process (13–16)

continues with new interactions, experiences, and feedback loops, ensuring the map remains dynamic and user-centered.

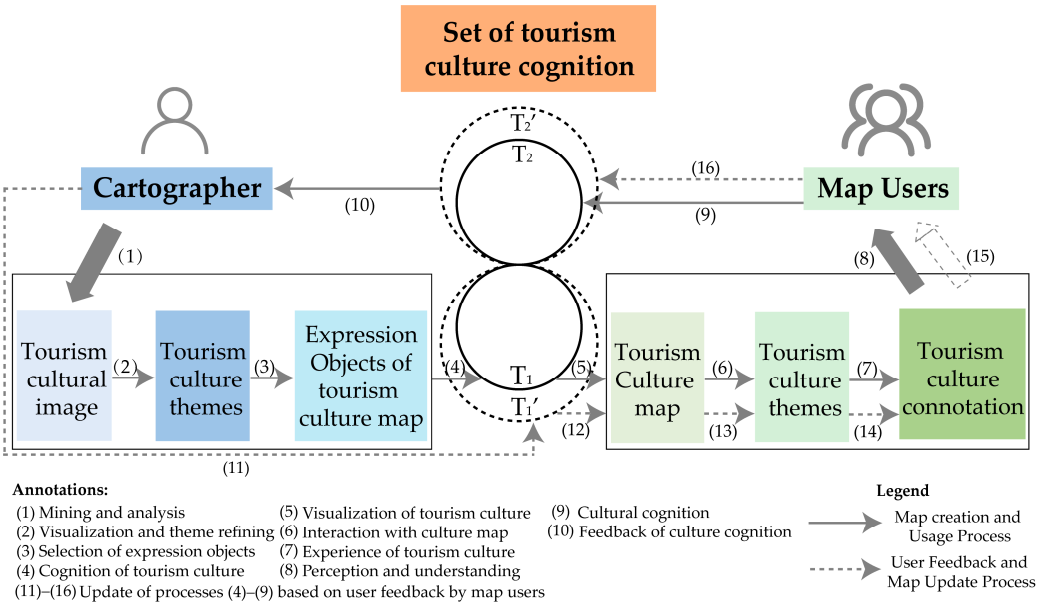


Figure 2. Information transmission model of tourism cultural map.

In this tourism culture map information transmission process, the cartographer produces the initial cognition T_1 of the tourist attraction culture and the new cognition $T_{1'}$ of the tourist attraction culture after the map user's feedback, and the map user likewise produces the corresponding cognition T_2, $T_{2'}$.

3.3. Mining and Visualization of the Tourism Cultural Image in Tourist Attractions

3.3.1. Composition of Culture in Tourist Attractions

There are differences in the understanding of culture in different schools of thought, and a unified definition has not yet been formed. As far as the tourist attraction space is concerned, due to the intertwined existence of "physical-spiritual" and "traditional-modern", culture has been deconstructed into four dimensions, with traditional culture being the culture of historical architecture, religious beliefs, and other cultures inherited from the tourist attraction area through the accumulation of historical development and modern culture being the advanced culture of science and technology, civilization norms, and other advanced cultures produced in response to the development of the times. While traditional culture contains physical and spiritual aspects, modern culture also covers these two dimensions, which are cross-connected and interpenetrated. The cultural composition of the scenic space is shown in Figure 3.

3.3.2. Mining and Content Analysis of Tourism Cultural Image

We adopt the content analysis method, based on the theory of "projection-perception" and "cognitive-emotional" dimension of tourism cultural image and takes the official WeChat public account articles and online travelogue text data released by tourists as the objects of analysis. On the one hand, through text content analysis, the text and non-quantitative social media data are transformed into quantitative data, and the valuable information behind them is mined from the cognitive dimension; on the other hand, through the analysis of affective attitudes, the emotional tendency is mined from the affective dimension, better to reveal the tourism cultural imagery of tourist attractions.

Social media data provide many ways of communication without the need for physical participants [44]. Users can freely express their opinions online, providing a platform for people from different countries and cultures to generate and share knowledge, information,

media, ideas, etc. [45]. As such, these platforms embody the characteristics of participation, personalization, and independence [46], providing rich metadata for the mining and analysis of tourism cultural image [47].

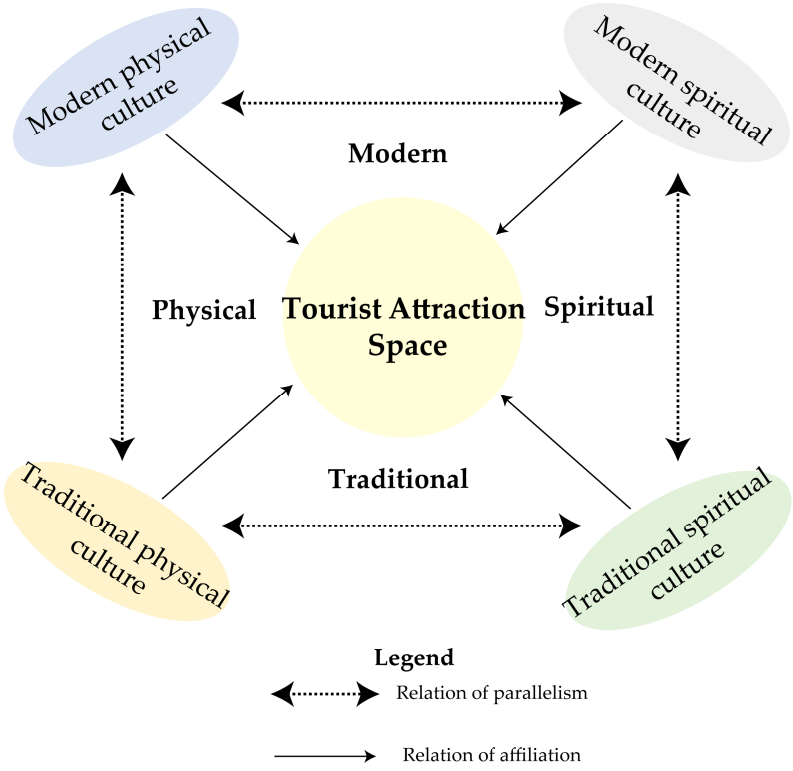


Figure 3. Cultural composition in tourist attractions.

Content analysis is a research method that describes communication content objectively, systematically, and quantitatively and can identify the quantity and quality of social media content dissemination, reflecting the focus of dissemination over some time as well as the tendencies, attitudes, and stances on specific issues and the changing law of dissemination content over a certain period. Currently, many software and program methods are used for the content analysis of texts, including CiteSpace, Leximancer, and ROST. Considering that the social media text data in this paper are Chinese text, which needs to be pre-operated, such as word division before analysis, and ROST CM6 is more friendly to Chinese text processing compared with CiteSpace and Leximancer [48], this paper chooses this software as a tool for content analysis. It carries out word division, word frequency, and sentiment analysis on the text.

3.3.3. Visualization of Tourism Cultural Image

(a) Cognitive Dimension

The cultural image of tourist attractions that mainly receives attention can be clarified through the statistical analysis of ROST participles and word frequency. Still, explaining the relationship between participles regarding meaning and deep semantic structure is challenging. Semantic network, as the use of social network analysis technology in text analysis, can reveal the implicit relationship between words or concepts that are frequently co-linear in the text, which is a kind of network graph that expresses knowledge through concepts and semantic relationships consisting of nodes representing concepts and edges representing semantic relationships between concepts, mapping or connecting semantic fields [49]. The visual presentation of the semantic network can more accurately reveal the internal associations of tourism cultural image and provide a basis for refining tourism cultural connotations.

(b) Emotional Dimension

The analysis and visualization of the emotional dimension focus on revealing the official attempts to convey the emotions of the tourism destination or the impressions and perceived attitudes of tourists towards the destination by analyzing the sentiment, nouns, and adjectives used in the text. Standard methods for emotional visualization include basic charts, river charts, heat maps, cloud maps, and radar charts. Among them, basic charts mainly show the distribution of emotional intensity through bar charts, pie charts, area charts, etc. [50–52]; river charts mainly show the changes in emotions over time [53]; heat maps can reveal the differences in data, which helps to differentiate between different types of emotions [54]; cloud charts can visualize keywords that appear more frequently in the text, which is suitable for understanding the core emotions [55]; and radar charts have a clear advantage in expressing multidimensional features in emotions [56]. Considering the analysis tools of this study and the aim of revealing the central emotional attitudes of tourism destination officials and tourists in the text, we chose pie charts to indicate the percentage of emotions and cloud diagrams to reflect the core emotions.

3.4. Map Expression Objects Selection and Visualization Design Framework

(a) Map expression objects selection from cognitive dimension

The perception method used in this study is unstructured and involves the projected image and perceived image through social media text data. The projected image text comes from the content generated by the scenic spot's official WeChat public account, and the perceived image comes from tourist-generated texts, i.e., network travelogues and comments.

For the social media text data, the primary methods for refining the tourism cultural image themes are (1) the multi-level coding method based on the rooting theory, which realizes the classification of the image theme through the open coding link [57]; (2) hierarchical clustering analysis method, which divides the text content into multiple clusters to make the similarity between the objects in the same cluster higher and then realizes the condensation of the tourism cultural image theme from the clustering results [58]; and (3) multidimensional scale analysis method, which uses the distance between words to determine the similarity and difference between the content of the image and then realize the categorization and identification of tourism cultural image [59]. This study uses the multidimensional scale analysis method to refine the theme of tourism cultural image.

The tourism cultural map design aims to show and interpret the tourist attraction culture and show the artistic connotation of the tourist attraction to the readers. Based on the tourist attraction cultural theme identification, the categories and sub-themes corresponding to the cultural theme are sorted out and continued to decompose a series of thematic contents to establish the map's expression object. For example, the category of natural landscape culture can be subdivided into sub-themes, such as "canals" and "gardens", "canals" sub-theme can be divided into "canal history", "canal distribution", and other thematic content, and then determine the mapping relationship between the text content related to it and the expression object of "canals", and according to the organization and structure of the text content to achieve the expression of the object of the organization and structure of text content.

(b) Framework of visualization design of tourism cultural map considering the emotional dimension

As shown in Figure 4, map readers use the map of scenic tourism culture, which is essentially the process of interacting with the scenic culture. Hence, the production of the map of scenic culture not only needs to consider the visual presentation of tourism culture imagery on the map but also the interaction between the map users and the tourism culture imagery. Scenic area culture contains material and spiritual layers, and the explicit characteristics of the material layer of culture make it the first and most accessible to be perceived by users. In contrast, the spiritual layer of culture is relatively abstract and

needs to rely on more experiential interactions. Brend Schmitt (Brend Schmitt) proposed the theory of cultural experience from the perspective of psychology, and he believed that cultural experience has five forms: sensory, behavioral, emotional, thinking, and association [60]. Considering the emotional dimension of tourism culture image and the interactive mechanism of the tourism culture map information transfer model in the context of the current map-bearing media presenting diversity and robust interactivity, this study proposes sensory interaction, behavioral interaction, and cognitive–emotional interaction, which triggers the user's shallow-to-depth interactive experience with the scenic area's material culture and spiritual culture. Among them, the material culture can be experienced through the primary senses, such as vision and touch; the spiritual culture can be experienced by triggering users' cognitive and emotional thinking about the culture. Behavioral interaction can connect these two kinds of cultural experiences so that users can interact with the artistic content of the tourist attraction through behavioral interaction and further deepen the experience.

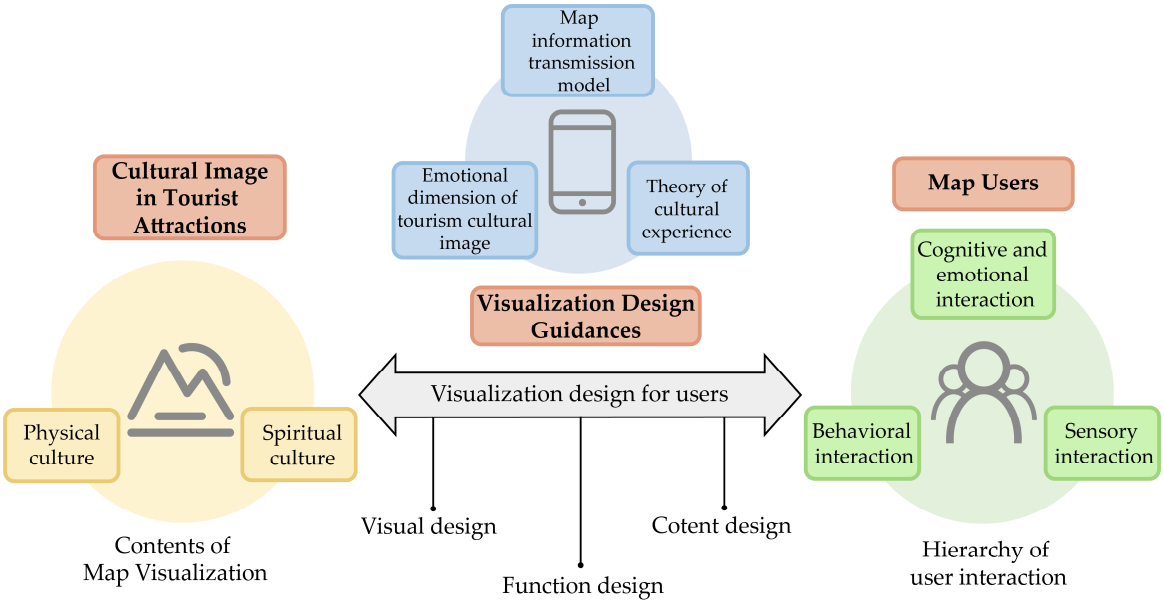


Figure 4. Framework of visualization design of tourism cultural map for tourist attractions.

3.5. The Procedure of Tourism Cultural Map Realization

The procedure for realizing the tourism culture map is shown in Figure 5. The procedure is divided into three parts: mining and visualization of tourism cultural image, map expression objects selection, and tourism culture map visualization design and implementation.

In the first part, the official text released by the tourist attraction and the evaluation text released by the tourists on the tourism website are collected as the source data for the projected image and the perceiving image acquisition. The official social media text data were obtained from the WeChat official account of the Nanjing Xuanwu Lake tourist attraction, the sample was intercepted from 1 March 2021 to 30 June 2022, and the tourists' comment text was obtained from China's three mainstream tourism resource recommendation websites, namely, Dianping.com, Mabee's Woo, and Ctrip. Crawlers were used to collect relevant official publicity and tourist comment text information from the WeChat official account of the Nanjing Xuanwu Lake tourist attraction and tourism resource recommendation websites. The details of the data are shown in Table 1. Based on the content analysis method, the collected texts were subjected to word splitting, cleaning, feature extraction, and analysis, and the cultural image of scenic tourism was extracted from the two aspects of cultural cognitive image and cultural emotional image. Then, the redundant information in the text was eliminated. Finally, it was converted to text file format

and imported into ROST CM6 software for statistical analysis. Before analysis, relevant place names, landscape names, and proper nouns were incorporated into a user-defined vocabulary.

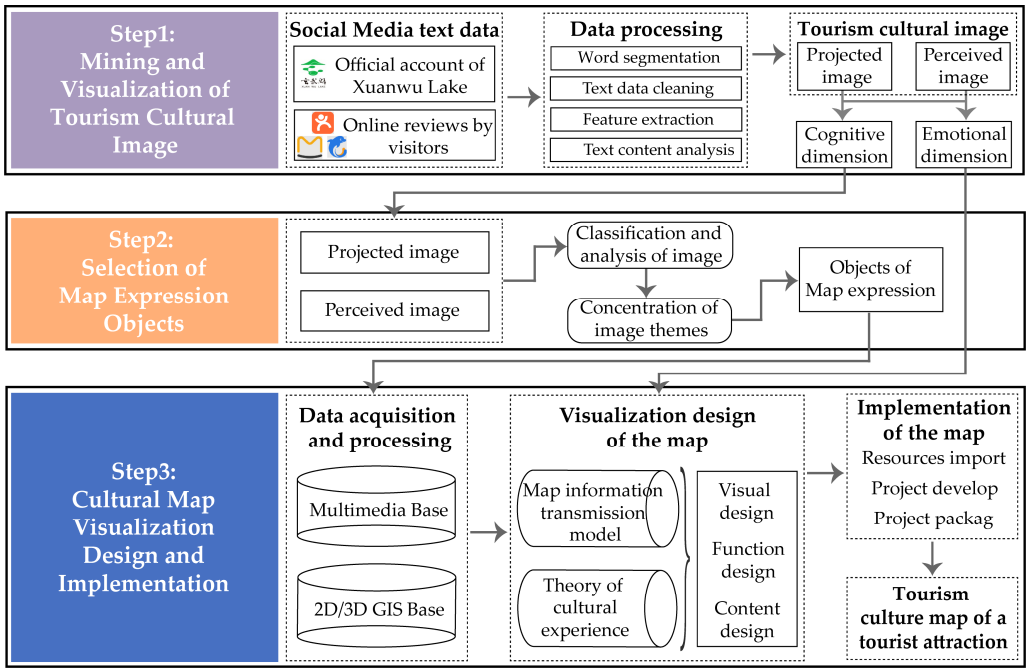


Figure 5. Procedure of tourism cultural map realization for tourist attractions based on mining and visualization of tourism cultural image.

Table 1. Data resources.

Type of Web Text	Source of Data	Volume of Data
Official web text	WeChat official account of Nanjing Xuan Lake scenic spot	432 articles
Tourists' comment text	Dianping.com	1569 comments
	Mabee's Woo	127 comments
	Ctrip	2992 comments

On this basis, the expression objects of the tourism cultural map are analyzed from the perspective of the cultural cognitive image. This includes classifying and analyzing the projected image and the perceived image and condensing the corresponding image theme, thus arriving at the expression object of the map.

In the part of visualization design and implementation of tourism cultural map, the multimedia information database and 2D/3D geographic information database are constructed through necessary data collection and arrangement; combined with the emotional dimension of tourism cultural image, the map information transmission model improved in this study and the theory of artistic experience, the visualization design of the map is carried out from the aspects of visualization, functionality, content, etc. Finally, the map is developed and deployed based on the relevant development tools such as Unity3D 2020. Finally, based on Unity3D and other related development tools, the map is developed and deployed to visualize the tourist and cultural image of the tourist attraction.

4. Experiment and Results

4.1. Analysis and Visualization Results of Cognition Dimension

For the cognitive dimension, we extracted high-frequency feature words from the WeChat public account texts of the Xuanwu Lake tourist attraction and tourist comments

through statistical analysis. Based on the extracted high-frequency words, we constructed the semantic network of the text based on the covariant word frequency. The visualization results are shown in Figure 6.

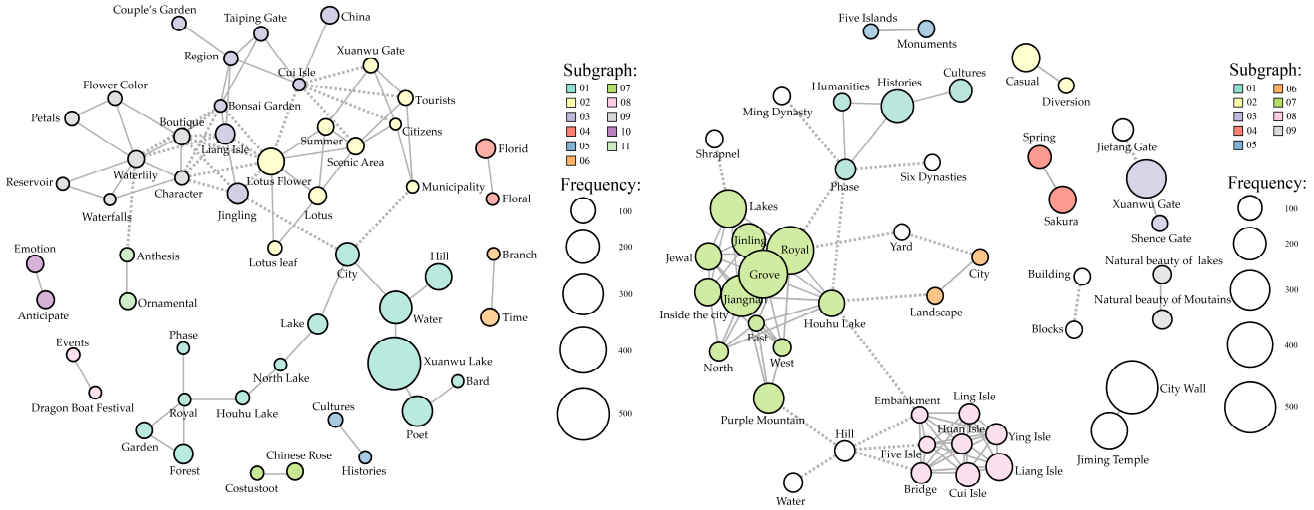


Figure 6. High-frequency word co-occurrence network of the cognitive dimension of tourism cultural image in Xuanwu Lake tourist attraction: (**a**) the result of the official dimension; (**b**) the result of the tourist dimension.

From the perceived results of the cultural cognitive image of the Xuanwu Lake tourist attraction, the official social media texts of the tourist attraction and the texts of tourist comments on the cultural cognitive image of tourism have a certain degree of inconsistency; the official texts centered the tourism cultural image around 'Xuanwu Lake', distributing various attraction characteristics evenly. Tourist comments highlight the 'garden', 'lake', and 'Xuanwu Gate', showing varying levels of attention and interest for each attraction.

4.2. Analysis and Visualization Results of Emotional Dimension

For the emotional dimension, the text of the Xuanwu Lake WeChat public account and the text of tourists' comments were categorized according to the emotions expressed: positive, negative, and neutral, respectively. The emotions expressed in the WeChat public account of Xuanwu Lake were predominantly positive, accounting for 94.93%. In comparison, neutral emotions accounted for 2.45% of the total, and another 2.62% carried some negative feelings. Tourist comments were also positive, with 73.04% expressing positive sentiments, 21.74% expressing neutral sentiments, and 5.22% expressing negative sentiments. Positive emotions dominated both official texts and tourist comments. This suggests a high degree of consistency between the emotional image perceived by tourists and the image projected by the officials. From the distribution of emotional image vocabulary, "poetic", "most beautiful", "good", "worthy", and other words with a positive emotional tendency appear more frequently (Figure 7).

4.3. Theme Refining of Tourism Cultural Image and Selection of Objects for Map Expression

Tourism cultural image research aims to align tourists' perceptions with the projected image from marketing organizations, with higher alignment leading to better results. Thus, deconstructing the tourism cultural image should focus on the projected image from official online texts. The goal is to find overlaps with tourists' perceived image close to the projected image. Therefore, this study first extracts the cognitive and emotional image projected by the destination marketing organization from the official online text and then takes the tourist's perceptual image as the object of the study to find the part of the tourist's perception that overlaps with the projected image or the perceptual image that is the most

interesting to the tourist in the projected image, i.e., image that conforms to the positioning of the image that is expected to be constructed by the tourist marketing organization and that is accompanied with the tourists' perceptual attributes.

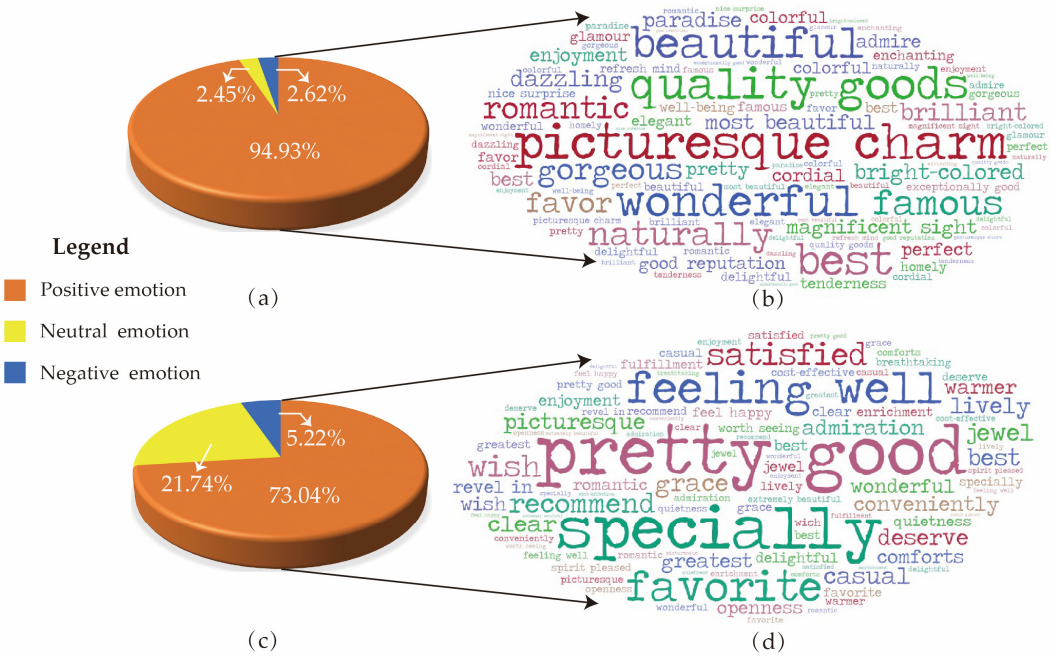


Figure 7. Emotional dimension analysis results of tourism cultural image in Xuanwu Lake tourist attraction: (**a**) the proportion of emotion of official dimension; (**b**) top 35 emotional words of official dimension; (**c**) the proportion of emotion of tourist dimension; (**d**) top 35 emotional words of tourist dimension.

Regarding the projected cultural image, this study subjectively categorizes the words mined from the cognitive and cultural image into four main categories: landscape cultural image, city wall cultural image, plant cultural image, and poetry cultural image. Among the four major themes, the higher frequency of occurrence is landscape cultural image and plant cultural image. In contrast, the city wall and poetry-related cultural images appear less frequently, reflecting a lower emphasis on these themes (Table 2).

Table 2. Refining of tourism cultural image themes from official dimension.

Cultural Image Theme	Feature Words of Cultural Image	Frequency of Feature Words	Feature Words of Cultural Image	Frequency of Feature Words
Landscape image	Xuanwu lake	336	water	14
	hill	42	lake	14
	north lake	14	houhu lake	39
	waterfalls	6	reservoir	7
	liang isle	31	cui isle	6
City wall image	xuanwu gate	14	taiping gate	19
	city	27	\	
Botanical image	lotus	12	lotus leaf	9
	lotus flower	25	bonsai garden	7
	waterlily	8	petals	11
	flower color	10	florid	34
	floral	6	branch	6
	costus toot	5	chinese rose	6
	anthesis	5	garden	22
	forest	13	\	
Poetic image	poet	8	bard	28

To refine the themes of tourists' perceptions, we combined objective and subjective approaches for a more comprehensive understanding of their impressions of Xuanwu Lake. Objectively, through the multidimensional scale analysis method of the tourists' perceptual image aggregation and categorization, the value of the pressure index is a crucial criterion to test the fit of the results. A pressure index between 0 and 0.2 indicates a suitable fit for multidimensional scaling analysis. Lower values suggest a better fit [61], and the value of the pressure index of 0.167, between 0.1 and 0.2, indicates that the multidimensional scale analysis results reach a general level, which is acceptable. The analysis results reach the general level, which is sufficient (Figure 8).

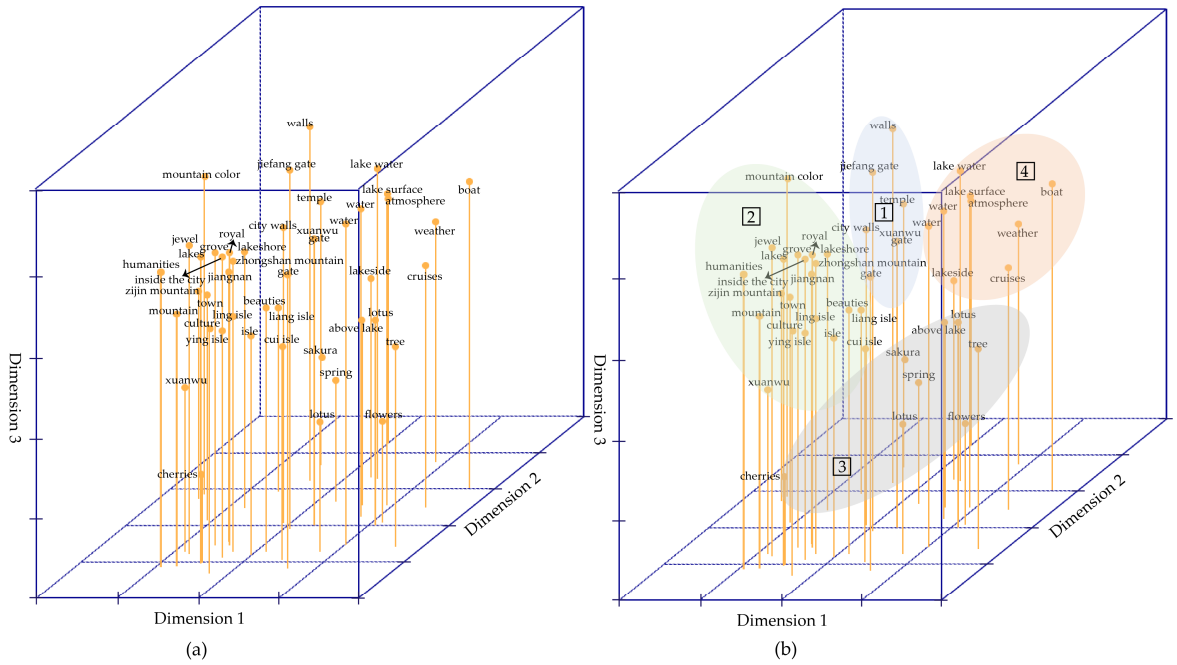


Figure 8. Refining cultural image themes from tourists' cultural image of cognitive dimension: (**a**) the result of multidimensional scale analysis; (**b**) the classification result of tourism cultural image based on the proximity of the words and the cultural connotations they denote. The "1–4" represents the four categories according to the remoteness of the words and their cultural meanings. "1" represents the perception of architectural culture related to the Xuanwu lake; "2" represents the perception of topography and geomorphology culture related to the Xuanwu lake; "3" represents natural vegetation landscape culture related to Xuanwu lake; "4" represents the water culture related to Xuanwu lake.

The multidimensional scaling analysis identified four categories grouped by the proximity of words and their cultural meanings. The first category relates to the perception of architectural culture, including landmarks such as the city wall, Jiefang Gate, and Xuanwu Gate; category two is about the perception of topography and geomorphology related to the Xuanwu Lake scenic spot, such as Zhongshan Mountain, mountain color, etc.; category three is about the perception of the natural vegetation landscape culture of Xuanwu Lake, such as lotus, cherry blossom, etc.; and category four is about the perception of Xuanwu Lake's water culture, such as the surface of the lake, the water of the lake, etc. Synthesizing the results of projected cultural image and tourists' perceived cultural image, we summarize the types of tourism cultural image of the Xuanwu Lake scenic spot as landscape image, city wall image, and botanical image. Further, it analyzes the cultural connotation, map expression content, manifestation form, and cultural types of this image, as shown in Table 3.

Table 3. Cultural themes and map expression objects selection results of Xuanwu Lake tourist attraction.

Category of Image	Tourism Culture Keywords (Cognitive Dimension)	Connotation of Culture	Content Setting	Form of Expression	Culture Type
Landscape image	Zhongshan, Purple Mountain, Mountain color	Leisure and entertainment	What tourists see and hear during the climb	Tourists enjoying the scenery and recreation in the process of climbing Purple Mountain	Modern spiritual culture
	Lake, lake water, water, cruise ship	Geopolitical changes	History of Xuanwu Lake	The thousand-year history of changes in Xuanwu Lake	Traditional spiritual culture
City wall image	City wall, Jiefang gate, Xuanwu gate	Ancient building	Anecdotes from the construction of the city gates	The construction of the city wall during the Ming and Qing dynasties was in full bloom, showing the city gate architecture	Traditional physical culture
Botanical image	Lotus, cherry, cherry blossom, garden	Natural landscape	Introduction to the vegetation and its distribution on Xuan Lake	Since modern times, Xuanwu Lake has become an oxygen bar in the city with its rich vegetation	Modern physical culture

4.4. Visualization Design of Tourism Cultural Map for Xuanwu Lake Tourist Attraction

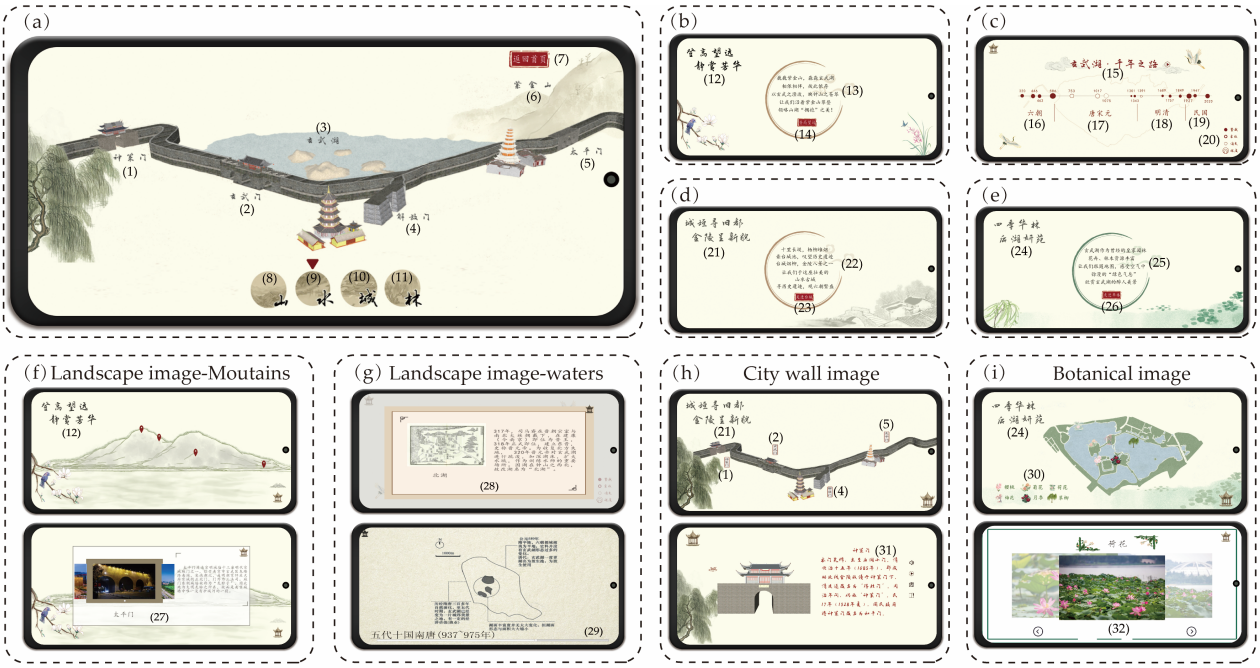
The visualization design of the Xuanwu Lake tourism cultural map revolves around three key components (Table 4): content, visual, and function design. The content design emphasizes themes such as the historical evolution of Xuanwu Lake, the cultural anecdotes from the construction of city gates, and the rich vegetation surrounding the lake. The design emphasizes tourists' experiences, from enjoying Purple Mountain's scenery to exploring ancient architecture and modern ecology. The visual design incorporates symbolic content through various expression forms, including 3D modeling, images, and hand-painted elements. These are presented using a carefully selected central color system tailored for optimal visual appeal, predominantly in greens and earth tones. Layout considerations are also integral, with specifications for screen size and orientation ensuring the map's effective presentation. The function design introduces various interactions, including gestures, feedback, and dynamic effects. These interactions are enhanced through anthropomorphism and scenario-based presentations, allowing for users to engage deeply with cultural elements through sliding, rotating, and scene-switching.

Table 4. Visualization design of the tourism cultural map.

	Content Theme				Content Details	
Content design	What tourists see and hear during the climb				Tourists enjoying the scenery and recreation in the process of climbing Purple Mountain	
	History of Xuanwu Lake				The thousand-year history of changes in Xuanwu Lake	
	Anecdotes from the construction of the city gates				The construction of the city wall during the Ming and Qing dynasties was in full bloom, showing the city gate architecture	
	Introduction to the vegetation and its distribution on Xuan Lake				Since modern times, Xuanwu Lake has become an oxygen bar in the city with its rich vegetation	
Visual design	Symbol content		Main Color system		Layout design	
	Expression Form	Example	CMYK	Color	Layout contents	Parameters
	3D modeling		31, 13, 12, 9		Screen size	2388 × 1080 px
	Pictures		49, 26, 51, 9		Screen orientation	horizontal
	Hand-painted		1, 0, 10, 0			
Function design	Type of interaction		Interactive presentation		Mapping of actions	Example
	Gestures		Anthropomorphism		Cultural image	Slide, long press, drag, rotate, click, etc.
	Feedback		Anthropomorphism		Cultural awareness	Feedback at interaction completion
	Toggle		Conversational		Cultural background	Momentary switching, theme switching, scene switching, content switching, etc.
	Dynamic effects		Scenario-based		Cultural scene	animation, operation instructions, video

4.5. Implementation of Mobile Interactive Tourism Cultural Map for Xuanwu Lake Tourist Attraction

As shown in Figure 9, the content design is structured around the interactive exploration of key cultural sites, such as the city wall, where users can receive operation instructions (a). The visual design incorporates various forms of interaction, including click, slide, and toggle functions (b,d,f), which allow for users to navigate through historical anecdotes, view animations (c), and toggle between different cultural themes (e). Function design further enhances the user experience by enabling gestures like long press, drag, and rotate (h), which provide an intuitive way to explore 3D models of cultural landmarks. The map also includes video integration (g) and scene-switching capabilities (i), offering a dynamic and immersive way to experience the cultural heritage of Xuanwu Lake.



Annotations:

(1) Shence gate
(2) Xuanwu gate
(3) Xuanwu lake
(4) Jiefang gate
(5) Taiping lake
(6) Zijin mountain
(7) Button of "return to home page"
(8) Button of "mountain part"
(9) Button of "water part"
(10) Button of "city wall part"
(11) Button of "botanical part"
(12) Title of "moutain part"
(13) Description of "moutain part"
(14) Button of internal content of "moutain part"
(15) Title of "water part"
(16) Text of "The Six Dynasties"
(17) Text of "Tang, Song and Yuan Dynasties"
(18) Text of "Ming and Qing Dynasties"
(19) Text of "The Republic of China (1912–1949)"
(20) The legend: From top to bottom are prosperity, decay, disappearance and degree
(21) Title of "city wall part"
(22) Description of "city wall part"
(23) Button of internal content of "city wall part"
(24) Title of "botanical part"
(25) Description of "botanical part"
(26) Button of internal content of "botanical part"
(27) Description of "Taiping gate"
(28) Description of "Northern lake"'
(29) Map of Xuanwu lake during the 937–975
(30) Legend of the plants: cherry, chrysanthemum, lotus, plum blossom, chinese rose, willow
(31) Description of "Shence gate"'
(32) Lotus pictures

Figure 9. Tourism cultural map development case: (**a**) the primary interface for map interaction; (**b**–**e**) interactive entrances corresponding to the four cultural themes of the Xuanwu Lake tourist attraction; (**f**–**i**) map contents for further cultural experiences for themes (**b**–**e**), respectively.

5. Discussion

This study provides valuable insights into the mining and visualizing of tourism cultural images, addressing critical challenges in effectively communicating cultural information to a broader audience. Utilizing an improved information transmission model for tourism cultural maps, this study addresses the gaps in the effective communication of cultural information between cartographers and map users. The proposed model improves the understanding of cultural elements and enhances the interactive experience of tourists, promoting more effective cultural dissemination. The case study of Xuanwu Lake in Nanjing, China, demonstrates the model's practical value in real-world cultural tourism settings. By mining tourism cultural images from social media texts and visualizing them through interactive mobile maps, this study demonstrates the potential to enrich tourists' cultural experiences. This approach provides a comprehensive framework that can be applied to other tourist destinations, fostering a more immersive and informed cultural exploration.

This research offers several advancements. Earlier studies primarily focused on the representation of cultural landmarks, often resulting in a homogenized depiction of cultural elements [10,11]. This study, however, emphasizes a dynamic and interactive approach, incorporating both cognitive and emotional dimensions of artistic images. Using

multidimensional scaling analysis and unstructured social media data provides a deeper understanding of tourists' cultural perceptions. Additionally, the feedback loop integrated into the information transmission model keeps the maps relevant, continually updating them based on user interaction to maintain a user-centered experience. This iterative process, updating the map based on user feedback, transforms static designs into dynamic tools, fostering continuous engagement and cultural learning [5,7,32].

Of course, this study has some limitations: (1) Currently, the data source for extracting tourism cultural images is limited to text, and future research should explore incorporating multimodal data, such as images, audio, and video, for a more comprehensive understanding [62]; (2) A reasonable evaluation index system needs to be established for the interactive scenic spot cultural map on mobile to realize the practical evaluation of the cultural communication effect of the map, and future research could also include comparative studies between different tourist destinations to evaluate the effectiveness of the proposed model across various cultural contexts, helping to refine the model's applicability; (3) We explored the cultural elements of scenic spots through tourism cultural image, and to some extent, we critically selected and analyzed these cultural elements when depicting them on tourism cultural maps, but whether the method aligns with historical accuracy and contemporary relevance still requires further study [13].

6. Conclusions

The excavation and visualization of tourism cultural images play a critical role in enhancing tourists' understanding of local culture and enriching their overall travel experience. This study presents an improved information transmission model for tourism cultural maps aimed at clarifying how to effectively convey tourism cultural information between cartographers and map users, thereby enhancing the cultural interaction experience for users. Based on this model, the research focuses on tourist attractions and further explores methods for mining cultural images guided by the expression of tourism cultural maps. A framework for selecting themes and designing interactive visualizations for cultural maps is proposed. Using Nanjing's Xuanwu Lake as a practical case, a mobile interactive tourism cultural map application was developed, demonstrating the feasibility of the proposed methods. Reflecting on the broader implications, this research highlights the need for tourism cultural maps to present information and engage users through interactive and emotional dimensions, fostering a deeper connection to the cultural heritage. This research will provide a theoretical basis and practical reference for visualizing tourism cultural image in tourism cultural maps.

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