

Multidimensional Visual Analytics System for Traditional Bamboo Weaving Craft

Rongju He^{1,2}, Ying Guo², Chenyuan Wu², Chao Chen^{1,2,*}

¹ Sichuan Key Provincial Research Base of Intelligent Tourism, Sichuan University of Science and Engineering, Yibin 64000, China

² Sichuan University of Science and Engineering, Yibin 64000, China

Abstract

Bamboo weaving culture is a vital component of China's intangible cultural heritage, renowned for its unique craftsmanship and regional characteristics that hold significant value for inheriting and promoting Chinese civilization. To strengthen the digital preservation and display of bamboo weaving culture, this paper proposes a multidimensional visual analysis system named "The Melody of Bamboo: A Thousand Weaves". First, we design novel visualization views integrating spatio-temporal distribution and network relationships to showcase the regional characteristics, material applications, and process correlations of bamboo weaving. Second, through correlational analysis of data such as craft processes and bamboo species traits, we enable multi-angle exploration of intrinsic connections and regional features within these techniques. Third, we incorporate an interactive process scroll for in-depth comparison, addressing the need to explore cultural connotations. Finally, we construct a multi-view linkage system to support multilevel analysis and comparison of craft characteristics. Case studies demonstrate that this visualization system effectively interprets regional characteristics and intrinsic relationships in bamboo weaving culture, offering a new technological pathway for digital preservation of intangible cultural heritage.

Keywords

Multidimensional Data Visualization; Intangible Cultural Heritage Preservation; Bamboo Weaving Culture.

1. Introduction

Traditional bamboo craftsmanship is a distinctive cultural symbol of Chinese folk culture, imbued with strong regional characteristics. It embodies the wisdom of the Chinese people and carries the unique cultural genes of China [1]. Bamboo weaving culture specifically refers to the cultural tradition of using bamboo as raw material to create various artworks and utilitarian items through weaving, inlaying, and other techniques [2]. As a typical carrier of traditional Chinese ecological wisdom, intangible cultural heritage bamboo weaving, with its logic of using bamboo as the material and adapting techniques to the material, naturally aligns with the concept of sustainable development. It serves both as a "living fossil" showcasing the cultural diversity of different ethnic groups in the global context, and as a practical case sample requiring focused protection and inheritance in the process of sustainable development[3].

Contemporary efforts in inheritance and presentation face a dual dilemma: On one hand, traditional bamboo weaving techniques are often displayed in relatively monotonous ways, primarily through static museum exhibitions and textual descriptions, making it difficult to fully convey their

craftsmanship essence. On the other hand, China's vast territory means bamboo weaving culture is closely linked to regional features. Different natural environments and social customs have fostered distinct bamboo weaving technique systems across the country. For instance, Shengzhou bamboo weaving features lifelike animal shapes with simple, vivid lines and unadorned style; Chengdu's porcelain-wrapped bamboo weaving boasts exquisite craftsmanship, fresh and elegant colors, and strong practicality; Zigong's Gong bamboo fans, Chongqing's bamboo silk painting curtains, and Quxian's bamboo character paintings all have long histories and profound cultural influence [4]. These diverse schools of techniques face systematic challenges during inheritance, including inconsistent skill standards, fragmented dissemination channels, and insufficient cross-regional exchange.

This paper employs data visualization methods and design to implement the visual analysis system "The Melody of Bamboo: A Thousand Weaves", presenting the multi-dimensional attributes of bamboo weaving culture through visual analysis. It provides a platform for users interested in the regional lineage of Chinese bamboo weaving to freely explore and deeply experience the diverse charm of bamboo weaving culture through interactive engagement.

2. Related Work

This section reviews relevant work from two main aspects: bamboo weaving culture research and multidimensional data visualization.

2.1 Bamboo Weaving Culture Research

Current research on the regional lineage within bamboo weaving intangible cultural heritage focuses mainly on digital display and virtual reality experiences. Scholars like Wang Cui et al [5]. point out limitations in current preservation and dissemination: static display methods result in superficial "viewing" effects, while digital practices often remain superficial, failing to achieve deep cultural "experiences." Taking the research on bamboo weaving digital design and intelligent construction proposed by scholar Zhu Guangliang as an example [6], it utilizes generative artificial intelligence, augmented reality (AR), virtual reality (VR), and other digital means to organically integrate the cultural connotations, traditional techniques, and industrial practices of bamboo weaving into digital ecological scenarios, thereby achieving the digital revitalization of bamboo weaving culture. However, existing preservation measures still primarily focus on single-level display and fail to deeply analyze the regional cultural characteristics inherent in traditional bamboo weaving intangible cultural heritage. They also fall short of systematically excavating the local knowledge systems and cultural lineage inheritance of bamboo weaving culture from the perspective of regional cultural origins.

Based on the background of cultural inheritance, this paper takes the nationally recognized intangible cultural heritage bamboo weaving techniques as an entry point. Rooted in local cultural genealogies, it systematically organizes the spatial distribution, craft techniques, and cultural attributes of bamboo weaving culture across multiple regions of China.

2.2 Multidimensional Data Visualization

Traditional embroidery patterns often have strong freehand brushwork characteristics. For designers, they do not pursue the perfect proportion too much, but pay more attention to the meaning of the pattern itself and the emotional effect brought by the pattern. Traditional embroidery patterns have a very strong freehand effect. In particular, part of the pattern only through some simple lines, to draw the content, can be very vivid expression of the original features. In the development of embroidery art, designers need to grasp the characteristic expression of freehand brushwork, recognize the inherent laws of things, and then show the profound connotation of embroidery art. Multidimensional data visualization techniques build upon traditional data visualization methods, employing one-dimensional, two-dimensional, and multi-dimensional forms of data representation to achieve associative analysis and presentation between different data contents [7]. Wang Hongwei et al [8].

designed a multi-dimensional visual analysis method for analyzing Jin Yong's chapter-style novels, analyzing source texts based on themes, plot, story settings, and characters. Ma Qiumei et al [9]. constructed a visual analysis system for Sichuan Opera culture, performing multidimensional visual analysis on data related to Sichuan Opera evolution and repertoire. Feng Dan et al [10]. conducted cluster analysis on ingredient composition and cooking techniques, enabling users to explore connections between recipes from multiple angles.

This work applies multidimensional data visualization technology to transform the discovered associations within bamboo weaving culture into visual image information. The aim is to assist users in efficiently comprehending the cultural connotations of bamboo weaving and systematically organizing the developmental lineage of bamboo culture.

3. Data and Tasks

This section begins with requirement analysis. Based on the analysis results, design goals are clarified, and appropriate data is selected according to these established goals.

3.1 Task Analysis

Current preservation efforts for bamboo weaving intangible cultural heritage face several fundamental challenges. In terms of cultural resource integration, recording standards for bamboo weaving techniques vary across regions. Key information such as school characteristics and process parameters is scattered, making it difficult to conduct systematic research on bamboo weaving culture from different areas and severely hindering the formation of a holistic understanding of bamboo weaving culture. As an important carrier of regional culture, the craft characteristics of bamboo weaving are closely related to the local natural environment, but this cultural dimension is severely overlooked in current preservation practices. This lack of understanding prevents the full manifestation of the cultural significance of bamboo weaving craftsmanship and affects the public's accurate comprehension of its value. Accordingly, this paper proposes the following systematic analysis tasks:

(1) Classification and Collection of Bamboo Weaving Culture:

Bamboo weaving techniques under intangible cultural heritage possess strong regional characteristics. Therefore, this project requires systematically organizing classification information on bamboo weaving types scattered across local literature and online resources.

(2) Analysis of Bamboo Weaving Multidimensional Data Associations:

The main bamboo materials used vary for each type of bamboo weaving. The characteristics of these bamboo materials are strongly correlated with the type of weaving. Information on bamboo weaving intangible cultural heritage includes bamboo weaving products, corresponding inheritors, corresponding process flows. This complex set of relationships needs to be collected and integrated.

(3) Visual Presentation and Interactive Exploration:

Present bamboo weaving culture visually and support user interaction for exploration. On this basis, users can explore the intrinsic relationships between bamboo weaving types and regions, the differences between local bamboo weaving and basic weaving steps, assisting users in gaining a more comprehensive understanding of the intricacies of intangible cultural heritage bamboo weaving.

3.2 Data Sources

Based on the analysis tasks, the data used in this paper includes bamboo species types and intangible cultural heritage bamboo weaving data, covering image, text, and video data resources. Text data focuses on fundamental research on bamboo species and weaving, encompassing both scientific records of species characteristics and geographical distribution, as well as content on bamboo weaving technique characteristics and regional distribution. Sources include the Flora of China, CNKI academic platform, China National Museum and various local museum official websites, supplemented by professional literature such as "The Art of Chinese Bamboo Weaving." Image data

includes bamboo species photos, bamboo weaving process diagrams, and images of intangible cultural heritage inheritors. Materials mainly come from the Plant Photo Bank of China (PPBC), China Intangible Cultural Heritage Network, and China National Museum official website. Video data collects dynamic recordings of intangible cultural heritage bamboo weaving processes, using cinematography to fully present the production steps and core techniques of traditional craftsmanship. Sources are primarily the China National Museum and China Bamboo Industry Association official website, providing a visual medium for the living inheritance and dissemination of bamboo weaving techniques, as shown in Table 1.

Table 1. Data Collection Table

Data Type	Data Content	Data Sources
Text	Bamboo Species Characteristics & Distribution; Bamboo Weaving Features & Distribution	Flora of China, China National Museum & other local museum official websites, "The Art of Chinese Bamboo Weaving," CNKI
Image	Bamboo Species Pictures, Bamboo Weaving Process Flows, Intangible Cultural Heritage Inheritor Pictures	Plant Photo Bank of China (PPBC), China Intangible Cultural Heritage Network, China National Museum official website
Video	Intangible Cultural Heritage Bamboo Weaving Process Flows	China National Museum, China Bamboo Industry Association official website

4. Data Processing

This project systematically integrates and processes the collected multi-source heterogeneous bamboo weaving cultural data. Information of various types-including bamboo species texts, craft literature, and audiovisual materials-was gathered from sources such as the Plant Photo Bank of China (PPBC), CNKI, China Intangible Cultural Heritage Network, China National Museum website, and China Bamboo Industry Association website. Text data was extracted from the Flora of China website, cleaned, and key parameters like bamboo length and fiber density were extracted to classify bamboo material characteristics. CNKI literature and books were integrated, using OCR technology for initial text extraction from printed materials. Subsequently, the DeepSeek model was used to distill information relevant to bamboo weaving types, characteristics, and techniques from the text. For image data, operations included background removal to highlight the subject, cropping to standardize sizes, and converting to a uniform storage format. For bamboo weaving process video data, operations included adapting resolution, using editing software to standardize encoding formats, and trimming. The processed data was then categorized and stored, as shown in Figure 1.

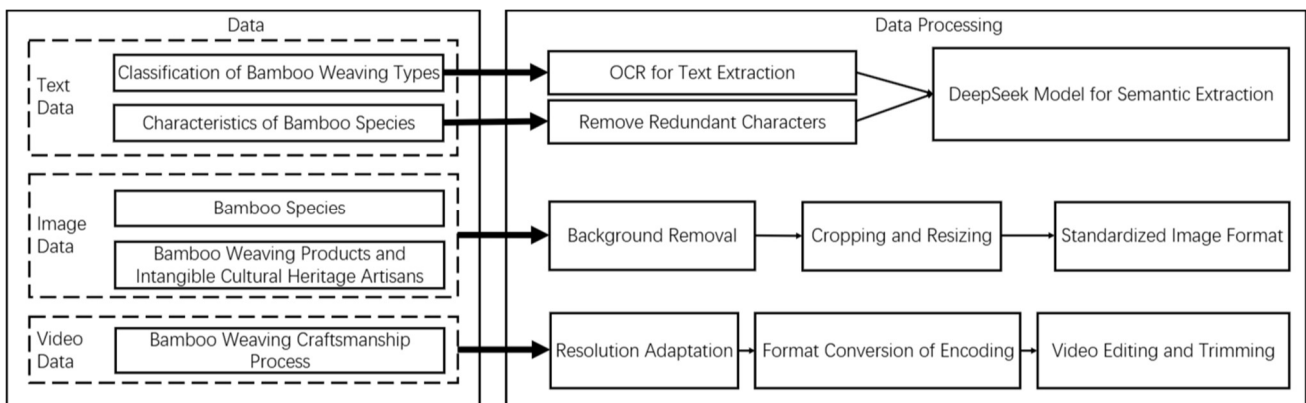


Figure 1. Data Processing Flowchart

5. Visual Analysis System

Based on the analysis tasks, this paper proposes a visual analysis system for traditional intangible cultural heritage bamboo weaving culture named "The Melody of Bamboo: A Thousand Weaves" as shown in Figure 2. It consists of a regional bamboo weaving technique association network view, composed of a bamboo species characteristic view and a bamboo weaving type classification view, along with a bamboo weaving technique comparison view that includes information presentation and an interactive process scroll for comparing regional and basic bamboo weaving techniques.

5.1 Bamboo Species Characteristic View

To present the regional distribution characteristics of bamboo weaving culture and the spatial relationships of bamboo species resources, a multi-dimensional visualization system needs to be constructed. Firstly, a layered geographic information map is adopted as the foundational framework, using an administrative map of China as the base map, corresponding to Area A in Figure 2. Area B in Figure 2 corresponds to bamboo species types and core material characteristics. A Sankey diagram is introduced to establish an interactive view between bamboo species and geographical distribution. When users click on a specific administrative region, the system highlights the characteristic bamboo species of that area, enabling multi-level information linkage from macro distribution to micro characteristics.

5.2 Bamboo Weaving Type Classification View

This design reveals the complex relationships between bamboo species characteristics, craft techniques, and regional schools through multi-dimensional visualization means. Area C in Figure 2 displays craft categories, covering the three major systems: flat weaving, three-dimensional weaving, and porcelain-wrapped weaving. It also includes an interactive bubble matrix representing bamboo weaving regional works. Clicking any bubble links to the inheritor information in Area D of Figure 2, enabling instant interaction and deep association of multi-dimensional information. Sankey curves incorporate visual elements of interlaced bamboo strips in the data flow, dynamically presenting woven textures. These curves link Areas A, B, and C in Figure 2, echoing the core design concept of bamboo weaving.

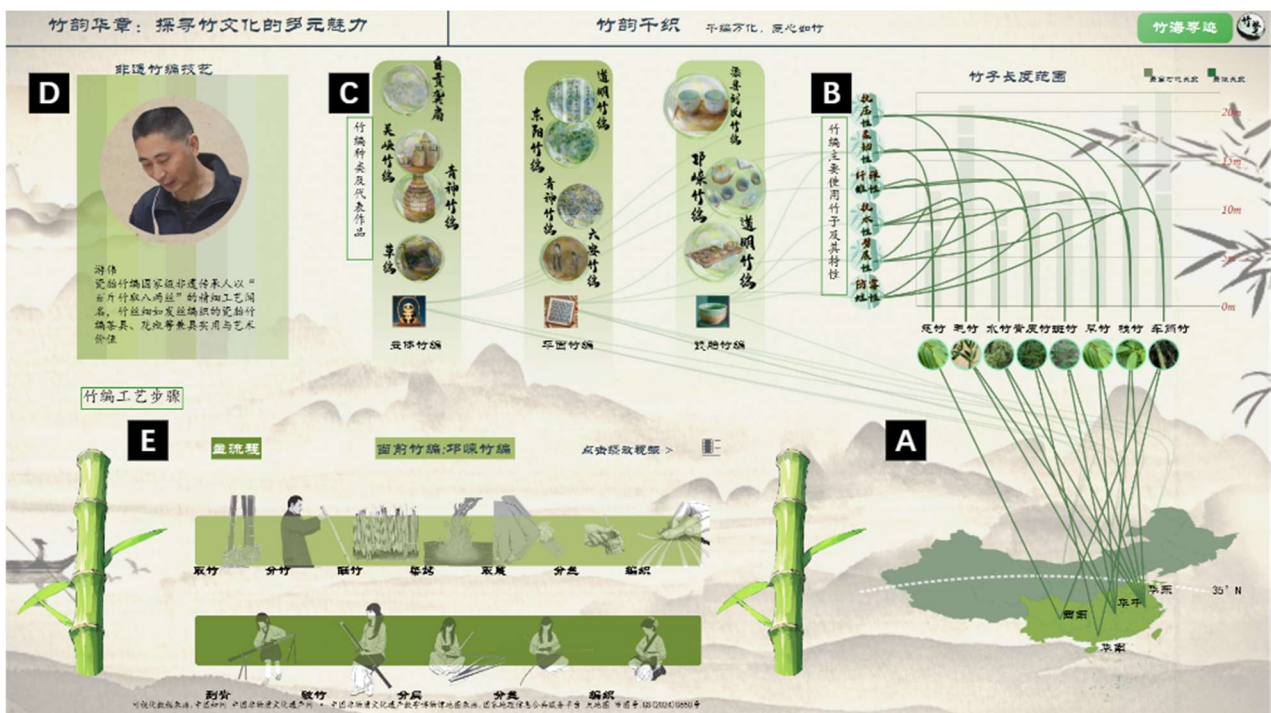


Figure 2. System overview diagram

5.3 Bamboo Weaving Technique Comparison View

Using an "unfurling process scroll" as the core interactive medium (corresponding to Area E in Figure 2), a dynamic scroll-style comparison interface is designed. This systematically displays specific regional bamboo weaving techniques, including but not limited to Sichuan Qingshen bamboo weaving and Zhejiang Shengzhou bamboo weaving. It also allows comparison with the main bamboo weaving process flows, delving into the internal mechanisms by which regional cultural factors influence the creative transformation of traditional bamboo weaving techniques.

6. Case Analysis

Based on two representative cases, this paper systematically explores the influence mechanisms of regional environmental factors on the formation of bamboo weaving types. The first case demonstrates the high correlation between bamboo weaving distribution and the natural distribution of bamboo plants, which is primarily constrained by regional climate conditions. The second case explains the regional reasons for the inheritance and development of porcelain-wrapped bamboo weaving techniques in Southwest China from a geographical perspective.

6.1 Influence of Climate on Bamboo Weaving Distribution

The main bamboo materials used in bamboo weaving include: *Neosinocalamus affinis* (Ci Zhu), *Phyllostachys heterocycla* cv. *Pubescens* (Mao Zhu), *Phyllostachys heteroclada* (Shui Zhu), *Bambusa textilis* (Qing Pi Zhu), *Phyllostachys bambusoides* f. *lacrima-deae* (Ban Zhu), *Phyllostachys praecox* (Zao Zhu), *Phyllostachys bambusoides* (Gui Zhu), and *Bambusa sinospinosa* (Che Tong Zhu). Constrained by climate conditions affecting bamboo growth-bamboo being highly sensitive to moisture, temperature, and soil conditions-the distribution of these species often exhibits distinct regional characteristics, as shown in Figure 3. Bamboo typically requires an annual precipitation of 1000-2000 mm, whereas regions north of latitude 35°N often receive less than 600 mm annually, insufficient for bamboo shoot germination and growth. Bamboo also prefers loose, acidic red soils, which are widespread in southern mountainous areas. Northern soils tend to be alkaline and clay-heavy, hindering rhizome expansion. Consequently, large-scale bamboo forests form mainly south of latitude 35°N, such as in East, Central, Southwest, and South China. The topography there, along with high humidity and sheltered locations, provides a "natural greenhouse" for bamboo groves, as illustrated in Figure 3.

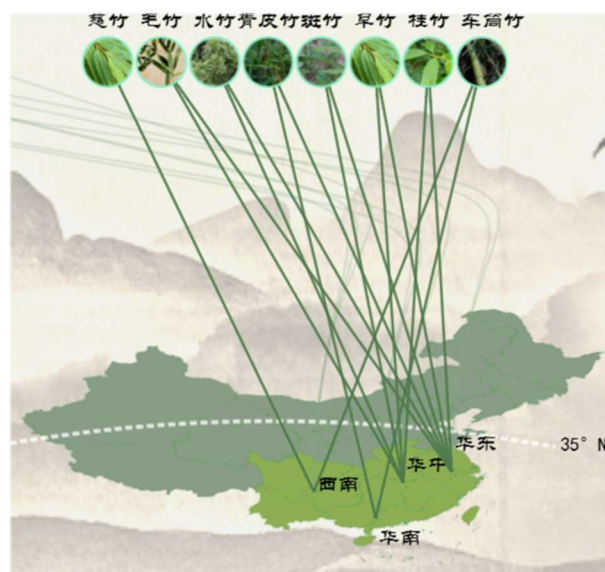


Figure 3. Distribution Map of Bamboo Weaving Raw Materials

6.2 Formation of the Regional Characteristics of Porcelain-Wrapped Bamboo Weaving

Porcelain-wrapped bamboo weaving, as a Chinese intangible cultural heritage item, is a unique traditional handicraft of Sichuan and an important intangible cultural heritage of the province. Its survival is highly dependent on the distribution of bamboo resources.

Taking Ci Zhu (*Sinocalamus affinis*) as an example, it is concentrated in the Southwest region. Its characteristics—flexibility, water resistance, splittability, and insect resistance—perfectly meet the demands of porcelain-wrapped bamboo weaving, making it the ideal material, as shown in Figure 4. Geographically, porcelain-wrapped bamboo weaving is highly concentrated in Southwest China, giving rise to bamboo weaving crafts such as Quxian Liu's bamboo weaving, Qionglai bamboo weaving, and Daoming bamboo weaving. This distribution precisely reflects that its formation relies on the specific resource traits of Ci Zhu (flexible and insect-resistant) in Southwest China and its deep binding with the local cultural ecology. Together, these elements form a complete inheritance chain of "natural material - craft practice - cultural gene."

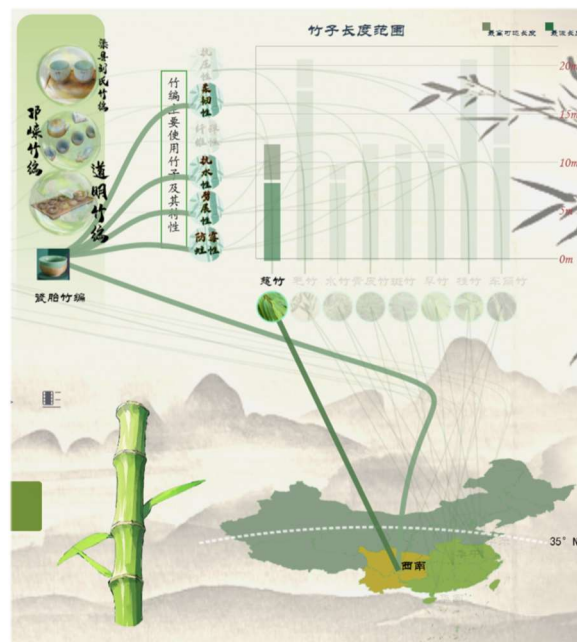


Figure 4. Relationship Diagram of Porcelain-Wrapped Bamboo Weaving

7. Conclusion

This work, starting from the multidimensional attributes of bamboo weaving culture, designed a visualization system "The Melody of Bamboo: A Thousand Weaves" that integrates spatiotemporal data and network relationships. By constructing multidimensional associative views for regional distribution, process flows, and bamboo material characteristics, it explores the strong regional characteristics of bamboo weaving culture. The system integrates multi-source heterogeneous data and employs innovative visualization methods such as bamboo weaving cultural relationship diagrams and interactive process scrolls, enabling a multidimensional analysis of bamboo weaving techniques—from ecological adaptability to cultural inheritance.

The method for analyzing intangible cultural heritage bamboo weaving culture proposed in this work exhibits significant transferability. It can be extended to related cultural heritage research fields such as bamboo carving and bamboo painting. In subsequent research, we will adopt a multidimensional cross-disciplinary perspective to deeply investigate the connections between social elements (such as folk practices and economic patterns) and the evolution of bamboo weaving techniques, thereby constructing an integrated regional knowledge genealogy.

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