ISSN: 2664-9640

Tracing the Threads of Bamboo Culture: A Visual Analytics System for Muti-Source Historical Data

Ying Guo[2], Rongju He[2], Chenyuan Wu[2], Mao Liu[2], Yuhang Song[2], 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 culture constitutes a significant component of Chinese civilization, possessing profound historical connotations and extensive influence. This study proposes a multi-source historical data-driven visual analytics system for bamboo culture. It aims to integrate fragmented, multi-temporal, and multi-dimensional bamboo cultural materials through visualization techniques, thereby intuitively presenting its developmental trajectory, social correlations, and cultural carriers. The system employs a time-series framework as its backbone, incorporating social data such as population, cultivated land area, and Chinese characters with the "bamboo" radical, along with information on cultural carriers including bamboo music, bamboo painting, bamboo poetry, and bamboo artifacts. An interactive interface featuring a Bagua (Eight-Trigram) inspired timeline coordinated with multiple linked views was developed, supporting users in exploring the historical evolution of bamboo culture from macro to micro perspectives. This research provides a novel technological pathway and visualization support for the digital preservation and public dissemination of bamboo culture.

Keywords

Bamboo Culture; Visual Analysis; Multidimensional Data Visualization; Time Series Data Visualization.

1. Introduction

Bamboo holds an extraordinary position within Chinese culture, traversing the extensive history of the Chinese nation and fostering a rich and unique bamboo culture [1]. Having undergone millennia of inheritance and evolution, bamboo culture has extensively permeated numerous fields, becoming an inseparable cultural gene within their developmental processes [2]. However, data related to bamboo culture-such as historical materials, documents, and images-is inherently characterized by disparate sources, diverse formats, and a loosely structured nature. Traditional methods of literature review and research struggle to systematically integrate these fragmented resources, let alone intuitively present the millennial evolution of bamboo culture. Furthermore, text-centric forms of communication make it difficult for the general public to quickly grasp its deeper connotations.

The 2016 IEEE VIS conference convened experts from the fields of digital humanities and visualization to discuss breaking down disciplinary and technological barriers between the humanities and sciences. This opened new pathways for the application of visualization technology in the digital humanities. These discussions laid a solid foundation for the development of bamboo culture visualization. Introducing data visualization techniques into bamboo culture research can leverage their strengths in intuitiveness and interactivity to systematically map the developmental trajectory of bamboo culture, thereby enhancing the

ISSN: 2664-9640

vividness and reach of its dissemination. This holds significant theoretical and practical value for deepening bamboo culture research and expanding its channels of communication.

The related work in this paper relies on data visualization technology to conduct in-depth exploration and structural integration of fragmented data related to bamboo culture. Through visualization design, it aims to achieve an intuitive representation of its developmental trajectory and multi-dimensional relationships. The goal is to explore effective pathways for expressing bamboo culture in the digital age and to provide new technological support for its preservation and dissemination.

2. Related Work

This section focuses on the integration of bamboo culture's historical trajectory with visualization techniques. Given that the compiled data exhibits distinct temporal characteristics and multidimensional attributes, the following review is structured around three key areas: research on bamboo culture history, time series data visualization, and multidimensional data visualization.

2.1. Bamboo Culture Historical Research

Current research on the history of bamboo culture primarily involves three aspects: the verification of its historical trajectory, the interpretation of its spiritual connotations, and the systematic sorting of its material carriers. He Ming[3] has systematically outlined the core developmental characteristics of Chinese bamboo culture from the primitive era through the Yuan, Ming, and Qing dynasties. Regarding the integration of bamboo culture history with technology, preliminary explorations have been conducted in existing studies. For instance, Li Xuan et al. [4], from the perspective of immersive experience, proposed digital presentation strategies such as spatial immersion and media-integrated immersion for bamboo culture, which were implemented in the "Zhuyuntang" digital renovation project. Xu Xinyi[2] suggested creating a "Historical Corridor of Bamboo Culture" utilizing VR/AR technology to facilitate cultural dissemination. The "Southern Sichuan Bamboo Sea" Museum employs diverse exhibition methods, including 3D simulation and digital technology, to present the connotations of bamboo culture.

In general, existing digital practices tend to focus more on innovating presentation forms, while in-depth exploration and systematic visual analysis of the historical trajectory of bamboo culture itself remain insufficient. This makes it difficult to comprehensively depict its trans-epochal and multidimensional developmental panorama.

This study takes the historical trajectory of bamboo culture as its foundation and uses the concrete carriers derived from it-such as music, painting, poetry, and artifacts-as its branches. It systematically reviews the historical evolution of Chinese bamboo culture from the Wei-Jin period to the modern era. The work aims to construct a cultural visualization pathway that not only traces historical depth but also enables multidimensional perception.

2.2. Time Series Data Visualization

Time-series data visualization refers to the representation of datasets with temporal attributes. Current mainstream visualization techniques include various formats such as Theme Rivers, scatter plots, and timelines[5]. For example, Li Xinzhe [6] employed the Theme River technique, using imperial reign periods as the horizontal time axis, to present the evolving emotional trends throughout the creative cycle of The Book of Songs. Ma Qiumei et al. [7]integrated time series with scatter plots and Sankey diagrams to dynamically illustrate the correlation between population changes in Sichuan and the fusion of Sichuan Opera vocal styles during the Ming and Qing dynasties, aiding in the exploration of how migration culture influenced the evolution of the opera. Zhang Wei et al. [8] combined the Five-Degree Marking method with timelines, using

ISSN: 2664-9640

visual encoding to present data on the rhythm, emotion, and temporal evolution of Song Dynasty lyrics, thereby supporting the analysis of the relationship between a poet's creative style and the historical context.

This paper applies time series data visualization methods to the analysis of bamboo culture development. Based on temporal annotations found in historical documents and archaeological records, and using an Eight-Diagram-inspired timeline as the layout framework, it visually presents the manifestations and evolutionary trajectory of bamboo culture across different historical periods.

2.3. Multidimensional Data Visualization

Multidimensional data refers to data variables characterized by multiple attributes. The visualization of such data involves transforming multidimensional or high-dimensional datasets into graphical or pictorial forms that are easily comprehensible to humans. For instance, Feng Dan et al.[9] designed a radially laid out multidimensional association view, which integrates data on recipe ingredients, cuisine flavors, and regional weather patterns. This design facilitates users in conducting in-depth analysis of the association rules within recipes. In another study, Ma Qiumei et al. [7] employed visualization forms such as Sankey diagrams and heatmaps to correlate multidimensional data, including the formation period of Sichuan Opera, repertoire themes, vocal style integration, and migration culture. Their approach clearly presents the historical evolution of Sichuan Opera and the development patterns of its repertoire. Additionally, Hu Huahua [10] combined Theme Rivers with time-series and scatter series to depict the historical evolution of stylistic trends and poet schools in Song Dynasty lyrics.

This paper leverages multidimensional data visualization techniques to systematically extend and expand the understanding of the historical trajectory of bamboo culture. The research will systematically review core data on bamboo culture from the Wei-Jin period to the modern era. It will integrate key social influencing factors from various periods, such as cultivated land area and population size. Ultimately, the goal is to present the inherent evolutionary patterns within bamboo culture history in an intuitive and clear manner.

3. Data and Tasks

This section begins with a task analysis to clarify the key issues currently facing the preservation and innovation of bamboo culture. Based on this analysis, design objectives are established, and subsequently, appropriate data resources are selected to support the construction of the visualization system.

3.1. Task Analysis

The formation of Chinese civilization is the result of endogenous evolution, representing a unification of its internal logic and historical logic [11]. Understanding the developmental trajectory of a civilization is key to discerning its cultural essence [12], while cultural development itself is constantly influenced and constrained by broader social factors. As a significant and deeply rooted branch of Chinese civilization, the development and utilization of bamboo resources in bamboo culture date back approximately ten thousand years, according to research[13]. However, constrained by the perishable nature of bamboo as a material carrier, not all facets of bamboo culture’s connotations have been preserved in tangible form. Instead, its essence is mostly scattered across textual carriers such as folk records, ancient texts, and archaeological evidence.To this day, there remains a lack of systematic historical organization and in-depth value extraction for this cultural heritage. Furthermore, scholars like Yu Guojing[13]have pointed out that current efforts in disseminating bamboo culture face issues such as limited channels and content. Existing methods predominantly rely on traditional

ISSN: 2664-9640

formats like books, academic papers, films, and documentaries, which often present content in a singular manner. There is an urgent need to leverage modern media technologies to achieve innovative breakthroughs in communication models.

Therefore, this paper proposes the following systematic analytical tasks:

1) Historical Analysis of Bamboo Culture. Establishing a clear developmental trajectory of the civilization is a prerequisite for gaining insights into its core cultural characteristics. By extensively collecting and systematically integrating multi-source historical data on bamboo culture, a relatively complete chronological development axis will be constructed. This will enable users to gain a deep, foundational understanding of the heritage and spiritual core of bamboo culture.

2) Exploration of the Relationship between Bamboo Culture and Social Factors. Cultural evolution is deeply interwoven with socio-environmental factors. By selecting and extracting key social data, this task aims to establish connections between these factors and the developmental history of bamboo culture. Leveraging visualization technology, the reciprocal influence mechanisms will be intuitively presented, assisting users in grasping the epochal characteristics of bamboo culture's development.

3) Integration of the Multidimensional System of Bamboo Culture. Bamboo culture has extended from practical utensils into spiritual symbols, forming diverse systems encompassing literature, art, music, and more. This task involves the data-driven organization of cultural carriers across these various dimensions to support a panoramic visual presentation of its rich connotations.

3.2. Design Objectives

Based on the aforementioned requirements analysis, three design objectives are defined for the system proposed in this paper:

1) Visual Traceability of Bamboo Culture's Historical Trajectory. The system will provide an overview of materials across various developmental stages of bamboo culture. It will delineate key historical phases from the Wei-Jin period to modern times, establishing a content organization framework centered on chronological progression. Interactive filtering features will be implemented to allow users to conduct in-depth explorations of the historical evolution of bamboo culture.

2) Visual Analysis of Socio-Environmental Correlations. By providing social data encompassing factors such as population, cultivated land, and Chinese characters with the "bamboo" radical, the system will construct multidimensional correlation charts. These visualizations will intuitively illustrate the interactive relationships between social data and bamboo culture materials, aiding users in comprehending the epochal characteristics of bamboo culture's development.

3) Visual Presentation of Bamboo Culture's Multi-dimensional Connotations. The system will present the spiritual connotations and material carriers of bamboo culture across different dimensions, including bamboo music, bamboo painting, bamboo poetry, and bamboo artifacts. A multi-dimensional data presentation system will be built, leveraging features such as linked charts, categorical filtering, layered representation, and robust interactive capabilities. This will guide users in autonomously exploring cultural content, thereby facilitating a deep understanding of bamboo culture's rich connotations.

3.3. Data Sources

Based on the analytical tasks of this system, the data employed in this study is categorized into three main types: historical documents on bamboo culture, multidimensional cultural carrier data, and relevant socio-environmental data.

ISSN: 2664-9640

Historical Documents on Bamboo Culture focus on academic research and historical records concerning the origin and developmental stages of bamboo culture. Their primary function is to construct a chronological development axis for bamboo culture, providing essential support for historical trajectory analysis.

Multidimensional Cultural Carrier Data are further subdivided by cultural forms such as bamboo music, poetry, bamboo painting, and utensils. Text-based data like bamboo poems and prose-poems are systematically collected from authoritative online platforms through web crawling techniques. Image-based data, including historical ink bamboo paintings and bamboo weaving artifacts, are sourced by matching with collection records from cultural resource databases. Together, these materials form the foundational corpus for multidimensional system integration and visual presentation.

Relevant Socio-Environmental Data encompass information such as population size, cultivated land area, and the evolution of Chinese characters containing the "bamboo" radical across different dynasties. This data is primarily utilized to explore the interactive mechanisms between social factors and the development of bamboo culture.

All data undergo validation and standardization processes to ensure the accuracy and logical consistency of the historical narrative construction, the exploration of social correlations, and the multidimensional visual presentation of bamboo culture.

Table 1. Bamboo Culture Data

Data **Category**	**Data Sources**
Bamboo Developmental Stages	China National Knowledge Infrastructure (CNKI), *Chinese* Bamboo *Culture*
Bamboo Music	Series Database of Traditional Chinese Music Resources, China Music Score Network
Bamboo Painting	National Museum of China and official websites of various local museums
Bamboo Poetry	Souyun Website, Chinese Classics Website
Bamboo Artifacts	China Archaeology Network, Intangible Cultural Heritage Network, and other official websites
Social Data	*Chinese Population History*, *Kangxi Dictionary, Shuowen Jiezi*

4. Data Processing

The data processing workflow for the bamboo culture visual analytics system is illustrated in Figure 1. During the data collection phase, based on research requirements for bamboo culture from the Wei-Jin to the Tang dynasties, the system gathers multidimensional data spanning literature, art, history, and socio-economics. This is achieved through digitization methods applied to sources such as poetry, bamboo music notation, relevant academic books, and historical documents. In the data processing phase, textual data from poetry undergoes processes including screening, word segmentation, and word frequency statistics. For data in formats such as bamboo musical notation, PDFs of books and papers, or images, OCR (Optical Character Recognition) technology is employed to extract textual and graphical information. Key data points such as population, cultivated land area, and artifact names are extracted from the literature using regular expression matching methods.Moving to the data analysis and mining phase, the processed data-encompassing text, time series, categories, and multidimensional attributes-serves as the foundation. Techniques such as statistical analysis, pattern recognition, and semantic association are applied to conduct in-depth exploration of

ISSN: 2664-9640

themes including the evolution of bamboo culture, its artistic manifestations, and its social correlations.Finally, in the visualization phase, leveraging front-end technologies such as D3.js, a multi-view interactive system is designed and implemented. This system incorporates visualizations such as an Eight-Diagram time series chart, a Pentatonic Rose chart for music analysis, a Bamboo Node chart depicting the development of bamboo painting, a classical poetry word cloud, and a usage scatter plot. This integrated system supports users in intuitively tracing the historical trajectory and social connections of bamboo culture from various dimensions.

5. Visual Analytics System

Based on the defined tasks and design objectives, this paper proposes and implements a bamboo culture history visual analytics system founded on multi-dimensional data fusion. As shown in Figure 2, the system interface comprises two primary components: the Dynastic Core Overview View and the Multi-dimensional Correlation View. Rich interactive features are incorporated between these views, ensuring both the system's usability and its capacity for exploratory analysis.

The analytical workflow follows a structured approach, beginning with an examination of the spatio-temporal trajectory of bamboo culture's historical development. The process starts with the multi-dimensional collection and integration of bamboo culture data from the Wei-Jin period to the modern era. Next, targeted visualizations are designed to organize different types of bamboo culture data, establishing a linked framework that connects a central Eight-Diagram Token View with multiple auxiliary views. Finally, through interactive operations such as dynasty filtering, users can progressively drill down from an overall historical overview to examine the cultural details specific to a particular dynasty. This completes the visual analysis of bamboo culture history.

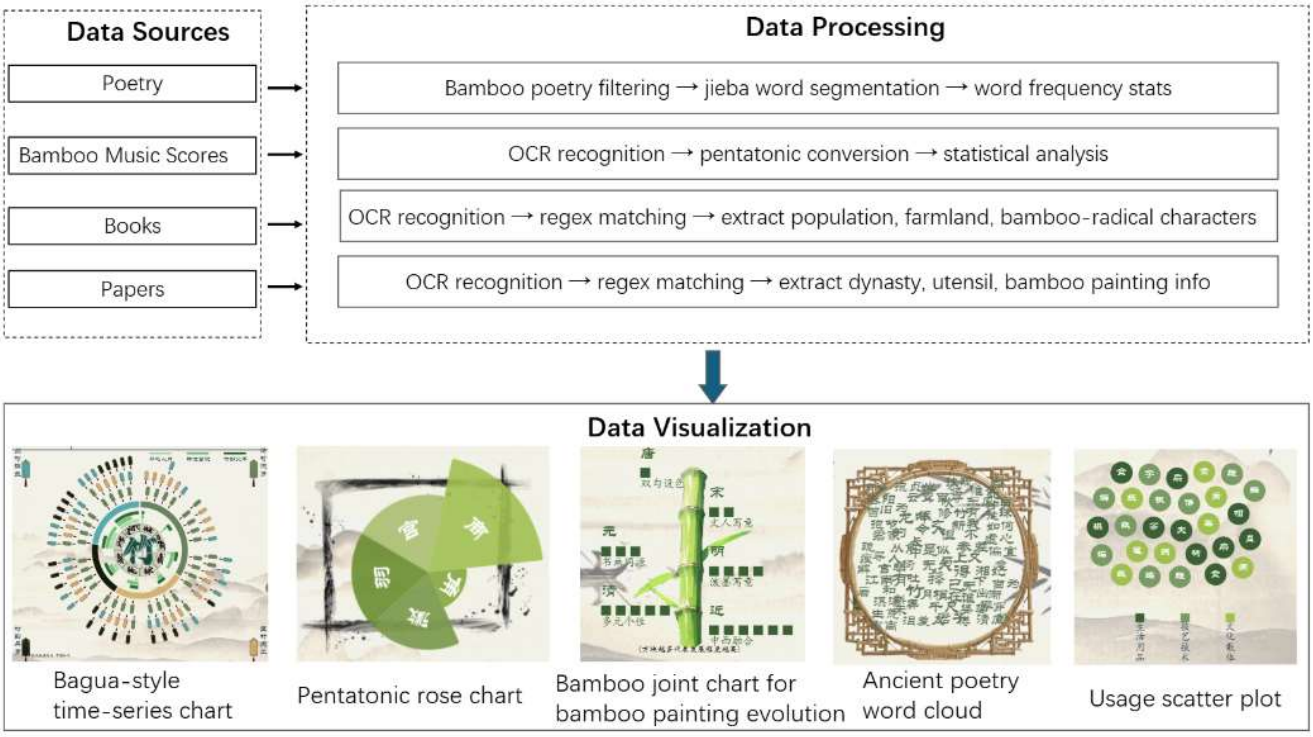


Figure 1. Visual Analysis Design Process

ISSN: 2664-9640

5.1. Dynastic Overview View

The Dynastic Overview View, located in region A of Figure 2, serves as the primary entry point for analyzing the historical trajectory of bamboo culture. This view employs an innovative layout inspired by the Eight-Diagram structure, with a multi-layered concentric ring as its core visual component. Progressing from the innermost to the outermost rings, the view sequentially presents data from the Wei-Jin period to the modern era, including average population, cultivated land area, the evolution of Chinese characters with the "bamboo" radical, and the proportional distribution of four cultural tokens categories. Additionally, various cultural theme tokens are distributed around the periphery. This design establishes a clear framework to support subsequent multidimensional analysis.

5.2. Multi-dimensional Correlation View

The views in regions B, C, D, and E of Figure 2 constitute the core auxiliary modules supporting the in-depth analysis of multidimensional bamboo culture information. These views dynamically present the evolutionary trajectories of various art forms, such as ink bamboo paintings, bamboo poetry, and bamboo-themed prose-poetry, across different dynasties. Specifically, the Pentatonic Rose Chart for Bamboo Music in region B focuses on the visual representation of the proportional distribution of the five notes, highlighting their characteristic prevalence. The Rectangular Style Chart for Ink Bamboo Painting in region C employs a design combining rectangular blocks with bamboo node motifs to intuitively display the stylistic evolution and developmental stages of ink bamboo painting works. Region D presents a Frequency Word Cloud for Bamboo Culture Texts, providing an intuitive visualization of the core thematic keywords across different dynasties. Region E utilizes a Scatter Plot for Bamboo Craft Usage to clearly present the categorical characteristics of bamboo craft applications. Furthermore, the system features rich interactivity. When a user selects a specific dynasty, all views in this multi-dimensional correlation interface update in real-time to present the corresponding analytical results. Additionally, users can select a specific token (e.g., from the overview view), and the system will simultaneously filter and display the content associated with that token across the linked views.

6. Case Study

The "Bamboo Rhythms Through the Ages" visualization system employs multidimensional data integration and presentation to clearly delineate the phased evolution of Chinese bamboo culture from the Wei-Jin period through the Tang Dynasty. This evolution is consistently and profoundly linked to shifts in the socio-environmental context, a core relationship that is intuitively traceable across the various interactive views of the system.

The developmental trajectory of bamboo culture closely correlates with socio-economic transformations. During the Wei-Jin era, despite certain advancements in the economy and culture of the southern regions, the overall socio-economic landscape remained characterized as one of "vast land with a sparse population" and a subsistence economy primarily based on "rice and fish." The cultural development in these regions still lagged behind that of the north. Under these conditions, the economic and cultural potential of bamboo resources was not fully realized, resulting in a period of relatively placid development for bamboo culture. The Tang Dynasty, particularly following the An Lushan Rebellion, marked a turning point. The pronounced southward shift of the economic and cultural heartland, coupled with profound societal restructuring, injected strong momentum into the evolution of bamboo culture. The latent economic and cultural value of bamboo resources flourished comprehensively, propelling bamboo culture into a phase of pronounced prosperity. As illustrated in Figure 3, the trend line representing cultivated land area during the Tang Dynasty shows significant

ISSN: 2664-9640

expansion and maintains a positive correlation with the quantity of cultural tokens, substantiating that economic development laid the essential material foundation for the cultural efflorescence.

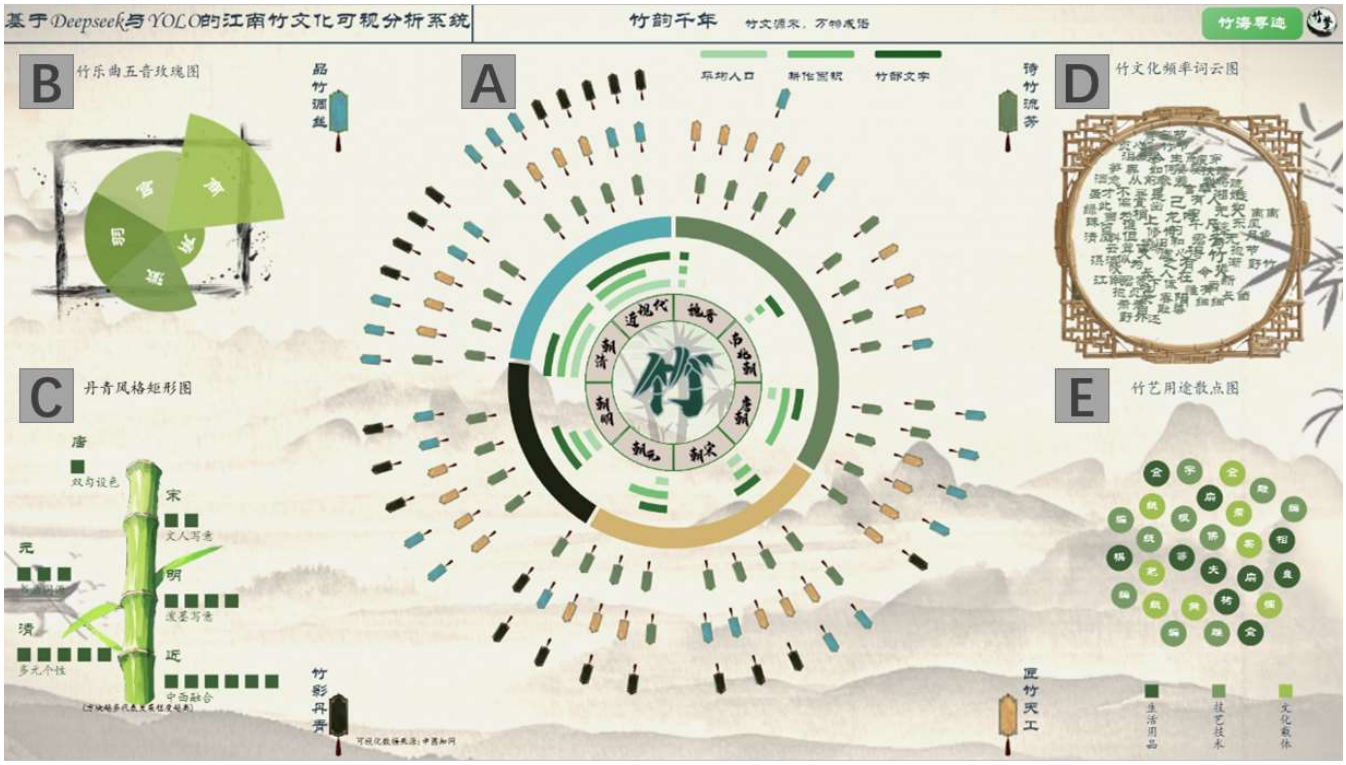


Figure 2. System Main Interface

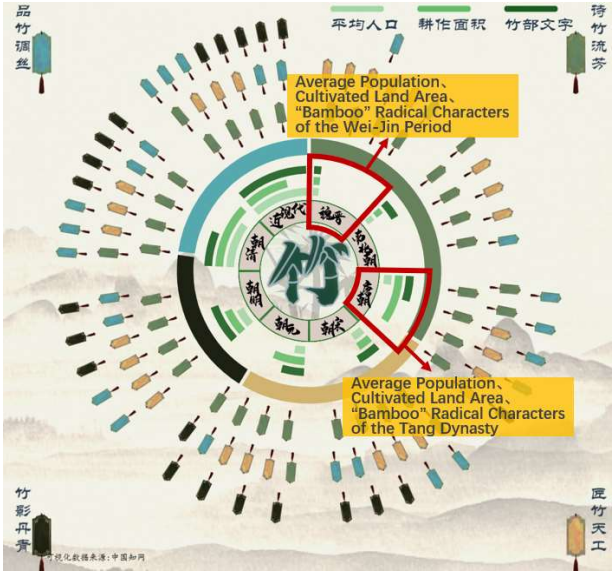


Figure 3. Eight-Trigram Overview

Examining the evolution of cultural functions, data on token distribution along the Bagua timeline for the Wei-Jin period reveals a high proportion of tokens categorized under "Crafted Bamboo: Nature's Artistry", which represent bamboo utensils and tools, as shown in Figure 4. This indicates that bamboo culture in this era was predominantly oriented towards practical utility. By the Tang Dynasty, the veneration of bamboo reached an unprecedented peak. System data demonstrates a significant increase in the proportion of green tokens representing

ISSN: 2664-9640

bamboo-themed poetry, as depicted in Figure 5. This shift signals a pivotal transition where the core of bamboo culture moved from practical applications toward the expression and sublimation of spiritual and aesthetic values. Concurrently, the art of bamboo painting began to emerge during this period, further evidencing the enrichment and maturation of bamboo culture in its artistic dimensions during the Tang era.

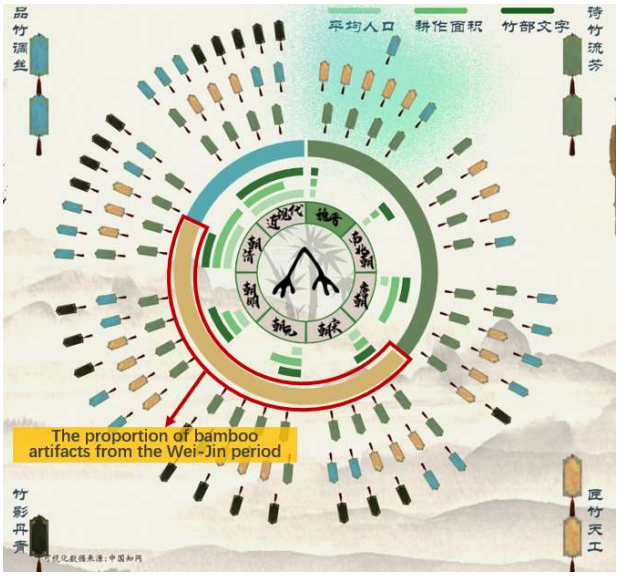


Figure 4. Eight-Trigram Diagram (Wei-Jin Period Example)

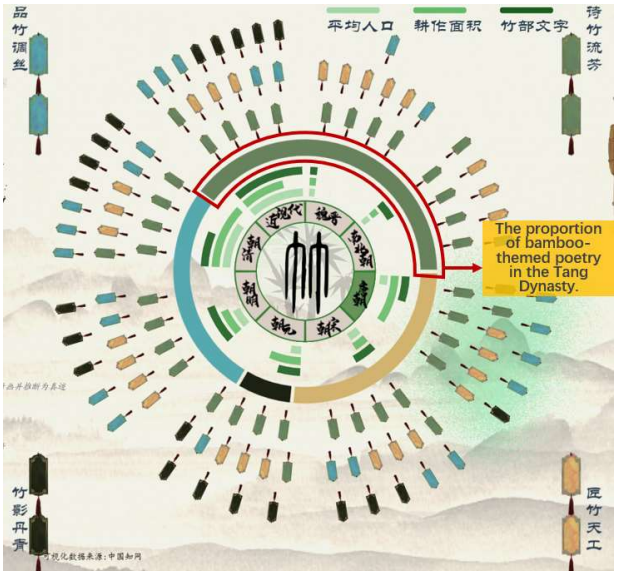


Figure 5. Eight-Trigram Diagram (Tang Dynasty Example)

7. Conclusion

This paper, centered on the construction and application of a bamboo culture visual analytics system, systematically elaborates on the methodologies for integrating multi-source historical data and the visualization pathways within bamboo culture research. The study focuses on three core dimensions: the historical trajectory of bamboo culture, its socio-environmental correlations, and its multidimensional cultural carriers. A visual analytics system was developed that integrates time-series analysis, coordinated multi-view visualizations, and interactive exploration. Through the categorized organization and visual representation of

ISSN: 2664-9640

spatio-temporal and multidimensional data, the system enables an intuitive tracing of the developmental trajectory of bamboo culture from the Wei-Jin period to the modern era and reveals the deeper connections between its evolution and social factors. The research validates the applicability of visualization technology in the digital humanities domain and also provides new methodological support for the systematic study and public dissemination of bamboo culture.

Currently, research on bamboo culture visual analytics is still in its nascent stage. Future work could be pursued in the following directions: First, in terms of interactive experience, by incorporating technologies such as Augmented Reality (AR) and Virtual Reality (VR), immersive platforms for bamboo culture presentation and storytelling could be constructed. Second, in terms of data analysis, introducing technologies like Natural Language Processing (NLP) and image recognition could enable deeper exploration into the semantic meaning, emotional connotations, and stylistic evolution within bamboo culture.

As an integral component of Chinese civilization, the digital preservation and visual expression of bamboo culture bear significant cultural significance and contemporary value. By constructing a visual analytics system based on multi-source data fusion, this study provides a feasible technological pathway for the dynamic presentation and public education of bamboo culture. It also offers a reference for the visual preservation and dissemination of other cultural heritages.

Acknowledgments

The authors gratefully acknowledge the financial supported by Sichuan Key Provincial Research Base of Intelligent Tourism, Sichuan University of Science and Engineering (No.ZHYJ24-05).

References

[1] Xia Enlong,Yu Tianfei.The Value Inheritance and Innovation of Bamboo Culture for the Spiritual Lineage of Communist Party of China Members[J]. National Academy of Forestry and Grassland Administration Journal,2025,24(03):16-23. (in Chinese)

[2] Xu Xinyi. On the historical inheritance and external communication of bamboo culture [J].New Legend, 2025,(33): 20-22. (in Chinese)

[3] He Ming. A Brief History of Chinese Bamboo Culture [J]. Root Exploration 1999,(02):13-16. (in Chinese)

[4] Li Xuan, Zhang Ying, Yang Hai-yun Research on Design Strategy for Digital Display of Bamboo Culture from the Perspective of Immersive Experience[J].Journal of Bamboo Research, 2024,43(02):71-83. (in Chinese)

[5] Chen Chao, WU Yadong, FU Chaoshuai, et al.Research on visualization of Chinese Baijiu culture[J] Big Data Research,2021,7(02):78-98. (in Chinese)

[6] Li Xinzhe. Research on the emotional visualization design of the book of Songs and its evaluation oriented to cognitive effi ciency[D]. Harbin: Harbin Institute of Technology, 2016(in Chinese)

[7] Ma Qiumei, Jiang Xingtao, Zeng Qifeng, et al. Visual Analysis of Sichuan Opera Culture Big Data [J/OL]. Journal of Computer-Aided Design & Computer Graphics, 1-12[2025-06-15]. (in Chinese)

[8] Zhang Wei, Tan Siwei, Liu Kai, et al. A new perspective on the study of literature(songci): text correlation and spatio-temporal visual analytics[J]. Journal of Computer-Aided Design & Computer Graphics, 2019, 31(10): 1687-1697(in Chinese)

[9] Feng Dan, Yue Xiaoqi, Qin Hongxing, et al. Visual Analysis of Chinese Cuisine Dietary Data [J]. Journal of Computer-Aided Design & Computer Graphics, 2023, 35(04):562-574. (in Chinese)

[10] Hu Huahua. Visualization design and research of the style and sects change of Songci[D]. Harbin: Harbin Institute of Tech nology, 2018(in Chinese)

ISSN: 2664-9640

[11] Cao Jiandun,Yue Xiaofeng.The Internal Logisc Interpretation of the Endogenous Evolution of Early Chinese Civilization [J].The Central Plains Culture Research, 2022,10(06):40-49. (in Chinese)

[12] Li, Xinwei. Preliminary Reflections on the Formation Path of the 'Chinese path' civilization [J]. Archaeology and Cultural Relics. ,2024,(06):59-67. (in Chinese)

[13] Yu Guojing, Zhu Shuying. The Surrounding Communication of Bamboo Cultural Symbols in China [J]. Journal of Guizhou Minzu University:Philosophy and Social Science ,2023,(06):160-174. (in Chinese)