

AIGC Empowering Digital Protection and Gene Genealogy Construction of Traditional Bamboo Weaving in Zhaoqing

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Abstract

With a history of over 1,000 years, Zhaoqing's traditional bamboo weaving is an important component of China's intangible cultural heritage (ICH). Its survival is threatened by rapid urbanization, a shrinking pool of master craftsmen, and fragmented historical documentation. This paper looks into if new developments in AIGC such as LLMs, generative visual models, 3D modeling methods, knowledge graph structures can help conserve digital information of the custom of weaving bamboo in Zhaoqing and reconstruct its genealogy. Fieldwork completed in 6 villages; we had structured dialogue with 34 of the most experienced elderly veteran master knitters & collected more than 2400 patterns in various archives and library books to build systematically. The result shows that 91.3% of them were right, they can be distinguished into the 17 main lineage contexts to make sense of progress in aesthetics. It's not just an analytic device, a bit more than AI-driven conservation of cultural heritages, it's a scalable digital genealogy to do investigation about the folk art heritage within each province in China.

Keywords

AIGC, bamboo weaving, intangible cultural heritage, Gene Genealogy, cultural preservation.

1. Introduction

Intangible cultural heritage (ICH) represents a vital component of mankind's invaluable cultural patrimony, which stays fragile and significant even amid its fleeting character through the ages. Based on the United Nations Educational, Scientific and Cultural Organization's definition and establishment of a global framework for the protection of Intangible Cultural Heritage in 2003, member states are required by convention to determine, document and preserve live practices, expressions, skills and knowledge recognized as belonging to the cultural identity of communities[1]. Among various traditional ICH heritage in Guangdong province of China, there is an exemplary case of this kind - the ancient art form of bamboo weaving from Zhaoqing city. However, the average age at which practicing weavers began their weaving is above 60 years. There are few young people who show interest in inheriting the craft, and efforts to record this knowledge remain scattered.

AIGC technology has opened up new Opportunities and Ways to protect cultural Heritage in addition to digitalization's approach. As opposed to the traditional methods that mainly rely on photos, videos, description collections, and other forms., AIGC (Artificial Intelligence Generated Content) technologies can acquire generalized knowledge from heritages artefacts through machine learning algorithms and then produce various forms of artworks or descriptions; It constructs relations between different kinds of content by building knowledge graph; Then it offers an interactive platform for visitors so as to promote culture dissemination activities[2,3]. Their relevance can be seen at work with the problems of practicing Bamboo-weaving Art, which is both about finished works as well embodied gesture knowledge, and other forms; it

also includes material judgment or other contents related to this matter. This paper explores the organisation of AIGC within a holistic protective system for the cultural heritage of Zhaoqing's bamboo weaving; How to extract craft genotypes and genealogy, and what actual effects are brought about on-site in practice.

2. Background and Literature Review

2.1. The Traditional Bamboo Weaving Heritage of Zhaoqing

Bamboo-fashion heritage in Zhaoqing became the cornerstone because it was based on local climate and economy. Dinghu, Guangning, Sihui district is the area with most concentrated weaving collectives in China, and they are mostly formed by the transmission of craft skills through domestic bond and occupational instruction framework without any official organizations. As far as history is concerned, organized bamboo handicrafts production here started from the Song period. In Ming and Qing dynasties when Zhaoqing became an important trading centre of the region, there was great demand for fibre goods such as baskets and rugs[4,5]. The craft employs diverse techniques including plain, twill, and hexagonal weaving, as well as complex 3D structures for baskets, tables, seats, and other items. Each has its own aesthetic norms, functional logic and tool usage rules; together they form the “Craft Genome”, defined in material cultural studies as the complete transmissible technical and aesthetic information enabling craft tradition reproduction[6].

Scholarly research on Zhaoqing bamboo weaving lags behind that on other Chinese crafts. Existing documentation is mostly descriptive, lacking analysis of the underlying generative mechanisms in the weaving process. This gap makes Zhaoqing a particularly valuable and urgent case for advanced digital preservation, serving as a prototype for similar crafts in Guangdong and beyond.

2.2. AIGC Technologies and Cultural Heritage Applications

The application of artificial intelligence to cultural heritage has a substantial and growing literature, though the use of generative AI models in ICH preservation remains relatively nascent[7,8]. Early works aimed at digitisation and retrieval through computer vision methods to classify artefacts or identify text content in historical documents. More recently, some studies have used GANs to reconstruct lost or damaged artworks, CNNs to recognize stylistic features of ceramics, and transformers for generating oral history text. The notion of “cultural genes” inspired by the analogy between cultural genomic science and bio-genomics, is gaining attention among designers, with scholars positing that craft traditions are information systems made up of isolatable elements, sequences, which can be reconstructed[9]. Knowledge Graph technology, which can organise entities and their relationships in an explicit manner through structure representation. It is highly effective at organising this kind of complex information from Chinese Medicine Heritage Genealogy, surpassing traditional flat archive queries and visualisations. This graph structure enables the creation of genealogies that simultaneously represent biology-like lineages, geographic diffusion, and stylistic changes within a unified knowledge framework.

3. Methodology

3.1. Data Collection and Field Investigation

Empirically, based on multi-stage fieldwork carried out from March to November 2023 among six different types of bamboo-weaving villages located in the city of Zhaoqing. A total of thirty-four master craftsmen were interviewed to collect biographical materials, records of the transmission lineages, descriptions of techniques and evaluative content on local varieties of weaving. Additionally, 2,463 physical-weaving samples were imaged at standardised luminous

conditions by means of a calibrated multi-axial-image Station, this resulted in high-resolution visual dataset suitable for computational analysis[7,8]. For three-dimensional Scanning with Structured-lights technology, it was performed on 186 chosen Objects, while 22 complete-Weaving Sessions were also filmed and recorded in Video form to provide Dynamic-process Data that complements static-Artifact Records. Table 1 lists all items of the collected information.

Table 1. Summary of Field Data Collection Across Six Bamboo Weaving Communities in Zhaoqing

Data Category	Quantity	Collection Method	Primary Use	Scope
Craftsperson interviews	34 individuals	Structured interviews	Genealogy tracing	6 communities
Weaving pattern samples	2,463 items	Multi-angle HD photography	Pattern gene extraction	All districts
3D-scanned artifacts	186 objects	Structured-light 3D scanning	Morphological analysis	6 communities
Weaving process videos	22 sessions	HD video recording	Technique sequence modeling	All districts
Historical archival records	147 documents	Library & archive survey	Temporal contextualization	Municipal/prov.

Table 1 shows that the data includes both the material and intangible aspects of culture to provide an all-encompassing analysis method. From the 147 historical archives obtained from various places such as the Zhaoqing Municipal Library, the Guangdong Provincial Museum, and weaver families' private collections, a long-term development context was established for modernisation to be situated in this time framework.

3.2. AIGC Framework Architecture

AIGC-driven framework proposed in this paper consists of the following four integrated parts: (1) Data ingestion and pre-processing; (2) Craft gene extraction; (3) Genealogy graph construction; (4) Creative generation and dissemination. The first layer of conversion transforms the heterogeneous inputs of photograph, scan, video and interview into a form compatible with subsequent machine learning processes. The second layer uses computer vision and natural language processing technologies to identify “weaving genes”, which are discrete, repetitive structures in the weft-patterns, techniques and material logics[7,8]. Among them, there are motif gene (recurrent visual pattern), Structural Gene (Weave Architecture characteristic), procedural Gene (handwork movements identifiable sequence) And Lineage Gene (stylistic signature can be traced back to mastership apprentice chain). The third layer applies knowledge Graph technology to organise the extracted Genes in a relationship Genealogy Network that connects craftsmen, Techniques, Locations and Time Periods and other forms, making it queryable and Visualisable. The fourth-layer deployment of trained generative models generates new designs and interactive educational Applications for these generations; thus making them more easily accessible to teachers, Designers as well as the general Public.

4. Craft Gene Extraction and Classification

4.1. Pattern Gene Identification

Pattern gene features were extracted from the dataset using a refined vision Transformer trained on 2,463 photograph samples augmented under controlled experimental conditions. Pattern genes are operationally defined as recurrent structures appearing in >3% of samples, identifiable via measured geometric boundaries or colour thresholds. The model used self-supervised contrastive learning to cluster visually similar sub-patterns without full manual labelling, skilled workers then relabelled clusters using local technical terminology. This hybrid computational-ethnographic approach yielded 73 distinct pattern genes in 9 primary typological families (Table 2).

Table 2. Classification of Identified Pattern Genes by Typological Family

Gene Family	Genes	Freq. (%)	Earliest Period	Geographic Area
Grid-based geometric	18	34.2%	Pre-Song Dynasty	Guangning, Sihui
Diagonal interlock	14	22.7%	Ming Dynasty	Dinghu, Guangning
Radial star form	11	13.5%	Qing Dynasty	Sihui, Duanzhou
Edge binding pattern	9	11.3%	Song Dynasty	All districts
Symbolic/ceremonial motif	8	8.6%	Ming Dynasty	Sihui
Three-dimensional structural	7	5.4%	Republican Period	Guangning
Composite hybrid	6	4.3%	Post-1949	Duanzhou

Table 2 Grid-Based Geometric Patterns Are the Most Common Gene Family; Therefore, it can be said that plain-weave grid structures serve as the foundation for many bamboo weaving variants practice. The relatively new emergence of three-dimensional structural and composite hybrid gene families in the republic period and after 1949, respectively, indicates that this traditional culture has a dynamic quality and is not fixed; there cannot be an idealised view of bamboo-weaving as merely historical relics.

4.2. Technique and Lineage Gene Analysis

Procedural data were derived from 22 video clips via a pose-identification algorithm to identify hand placements, bamboo-stick paths and instrument motions, with operational segments dividing continuous weaving phases. This research discovered approximately 31 recurrent procedures throughout all Guangdong weaver villages, although particular procedural orders differ between groups inside the same village according to interviews. Integrating pattern recognition and interview-centered procedure grouping for lineage genetic examination of Zhaoqing weaving legacy households recognized 17 autonomous multi-generational lineage clusters. The overall pattern recognition accuracy reached 91.3% on 246 expert-labeled validation samples, comparable to other cultural heritage deep learning applications.

5. Gene Genealogy Construction and Digital Knowledge Graph

5.1. Knowledge Graph Architecture and Population

Zhaoqing bamboo-weaving gene genealogy was formalized as a directed knowledge graph with nodes representing entities - craftspersons, techniques, gene clusters, locations, periods,

artifacts - and edges denoting typed relations like “taught”, “developed from”, “characteristic of”, “produced in” and “dated to”. The graph used automatically generated triples from processed interviews and hand-selected, curated triples by the research team and experts[3,9]. Graph population proceeded iteratively through a deduplication and entity resolution pipeline, resulting in a structure containing 4,872 nodes and 12,340 typed relationships. Table 3 summarizes the structural composition of the knowledge graph by node and relationship type.

Table 3. Knowledge Graph Composition by Node and Relationship Type

Entity / Relationship Type	Count	Share (%)	Primary Data Source
Craftsperson nodes	312	6.4%	Interviews, archival records
Technique / gene nodes	247	5.1%	Pattern extraction, video analysis
Artifact nodes	1,843	37.8%	Photography, 3D scan data
Geographic location nodes	89	1.8%	Fieldwork, historical maps
Time period nodes	47	1.0%	Archival research
"Taught" relationships	2,341	19.0%	Interview data
"Developed from" relationships	1,876	15.2%	Comparative analysis
"Characteristic of" relationships	4,218	34.2%	Pattern-lineage correlation
"Produced in" / "Dated to"	3,905	31.6%	Archival and field data

The knowledge graph architecture described in Table 3 enables multi-hop relational queries that are not possible with conventional flat databases - for example, identifying all artifacts associated with a specific lineage branch that incorporate a specific pattern gene family and pre-date 1950. These abilities are among the most notable achievements of the knowledge graph method in genealogical cultural heritage research[4,5], allowing researchers and others in the community to explore the history of traditional culture using its relational structure instead of static keyword searches only.

5.2. Generative Applications and Heritage Dissemination

After establishing the genealogy framework of AIGC, this part will investigate its generating capabilities in terms of heritage dissemination and creative rejuvenation. A latent diffusion model was fine-tuned on the curated pattern-gene dataset to control the generation of new bamboo-weaving Designs with a sense of structure in accordance with the logical rules and aesthetic norms of identified lineage branches[2,7]. Expert evaluation of 300 generated designs by a panel of five master craftspersons found that 78.3% were judged as “culturally coherent” - recognizably consistent with Zhaoqing weaving tradition - while 21.7% were rated as culturally incongruous or technically unfeasible. The above-mentioned examples have confirmed that generative AIGC models based on proper domain-specific training data and structured genealogical constraints are more likely to be used as creative assistants for heritage protection rather than archival systems[4,10].

6. Results and Evaluation

System Performance and Expert Assessment

The integrated AIGC framework was evaluated along three dimensions: technical performance, heritage fidelity, and user accessibility. Table 4 presents the full set of system performance metrics. As shown in Table 4, pattern recognition accuracy exceeds 91%, knowledge graph query response times average under 2 seconds for single-hop queries, and generative design cultural coherence reaches 78.3%[4,6].

Table 4. System Performance Evaluation Metrics

Evaluation Dimension	Metric	Value	Reference / Benchmark
Pattern recognition accuracy	F1 score (test set)	91.3%	Expert-labeled ground truth
3D reconstruction accuracy	Mean surface deviation	0.43 mm	Calibrated reference object
KG query speed	Avg. response (single-hop)	1.87 s	Real-time usability standard
Generative design coherence	Expert-rated cultural coherence	78.3%	5 master craftsman panel
Lineage classification accuracy	Correct lineage assignment	86.7%	Interview-derived genealogy records
Information retrieval precision	Precision@10	0.84	Standard IR evaluation protocol

Genealogical Classification is accurate at only 0.867 which, despite barely being under pattern recognition, still indicates that it's naturally hard to classify based on who a person is due to historical fragmented record on artisans skill passing down from kind or area. This follows similar logic to other work on craft heritage - perhaps equally, recognize: art progresses and multi-ancestral passing have two different genealogies. The analytical assessment about the state of cultural preservation by doing structured examination towards 8 elderly artisans and 2 nearby culture authority found out there were some small deficiencies regarding the intellectual level but those differences came more from mistakes during interviews like human errors or misunderstanding rather than purposeful secrecy.

7. Discussion

Implications for ICH Digital Protection Practice

Several crucial insights into how to protect intangible cultural heritage by means of digitisation based on these findings. Firstly, based on the gene genealogy framework, it is demonstrated that AI-Graphics techniques can operate beyond artifact documentation and enter a more profound level of structural knowledge acquisition to extract aspects such as the generative law of pattern creation and transmission paths for traditional craftsmanship technology; The geographical differences in style formation[1,10]. Second, the hybrid computational-ethnographic methodology suggests that the most productive approach to AIGC-assisted heritage work is one in which machine learning systems and human knowledge holders work in complementary roles, each compensating for the limitations of the other.

Third, the knowledge graph architecture provides a scalable and extensible digital infrastructure that can continue to grow as additional data is collected, unlike static documentary records that become outdated and difficult to update[3,9]. Additionally, key issues in cultural authenticity and intellectual property protection require heritage

researchers' attention as AI-generated content development within this framework advances. Community ownership of AI designs derived from traditional cultural practices must be addressed promptly; governance frameworks should include attribution, profit-sharing, and community control over commercial use of AI cultural content from ancestral craft knowledge.

8. Conclusion

This study shows that AIGC technologies, when organised systemically into a consistent multidimensional framework and based on strict ethnographic field work, can achieve considerable significance for digital preservation as well as interpretive comprehension of the traditional bamboo weaving culture in Zhaoqing; The four-layer model (data acquisition, gene extraction, genealogy establishment, generative application) is scalable, adaptable and applicable to other cultural artefacts facing similar record loss and preservation challenges. Identifying 73 pattern genes in nine families, building a knowledge graph with 4,872 nodes and 12,340 relations, finding 17 distinct lineage branches, and proving culturally consistent generative design are major breakthroughs for this system beyond mere documentation in recent years.

Important limitations remain: the dependence on elder craftspersons as primary knowledge sources introduces survivor bias, the computational gene extraction methodology necessarily simplifies the richness of embodied craft knowledge, and questions of community ownership and cultural ethics in AIGC-assisted heritage work remain incompletely resolved. Future research could integrate more interactive co-design participation, explore multimodal technologies including sound and image, and engage with AI cultural creation laws and ethics. Long-term follow-up studies of craft practice changes and stage-specific community perceptions will strengthen evidence for such interventions. Zhaoqing Bamboo-weaving Digital Protection is not only an urgent practical need but also fertile ground for advancing AI-driven intangible cultural heritage research.

Acknowledgments

2026 Zhaoqing Philosophy and Social Sciences Planning Project: AIGC-Enabled Digital Preservation and Genealogical Map Construction of Zhaoqing Traditional Bamboo Weaving. AI-Driven Design and Application of Guangzhou Mazu Cultural and Creative Products in the Context of Cultural and Tourism Integration; Project No.: 2025GZGJ268.

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