

AIGC-Enabled Innovative Design of Traditional Cloisonné Patterns: Semantic Analysis, Digital Translation, and Practical Pathways

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Received: 15 January 2026; **Accepted:** 27 February 2026; **Published:** 7 April 2026

Abstract:

Traditional cloisonné motifs face semantic, stylistic, and application challenges. This study proposes a motif-centric AIGC framework: “semantic deconstruction–digital translation–practical verification”. 867 artifacts were analyzed to extract visual, semantic, and craft features. AIGC achieved 91.7% visual similarity and 89.2% semantic retention. Translated motifs scored over 85/100 in semantic inheritance, aesthetic adaptation, and craft feasibility, with 9.8× higher design efficiency than manual work. This provides a quantifiable pathway for cloisonné digital preservation.

Keywords:

Cloisonné, Traditional Motifs, Cultural Semantics, AIGC, Digital Translation, Intangible Cultural Heritage

1. Introduction

1.1. Research Context: Cultural Value and Inheritance Challenges of Cloisonné Motifs

Cloisonné motifs are not merely decorative symbols but visual carriers of traditional craft wisdom and cultural spirit. When cloisonné was first introduced to China during the Yuan Dynasty (13th century), its motifs were influenced by Arab culture, featuring “geometric interlocking patterns” with rigid lines and vivid enamel colors (e.g., Cloisonné Censer with Interlocking Lotus Patterns in the Palace Museum’s collection, with a dark blue background purity of 85% and interlocking stem curvature $\leq 30^\circ$) [14]. During the Ming Dynasty (14th–17th centuries), motifs gradually “sinicized”: the number of petals in interlocking lotus patterns was fixed at 12–16, and dragon motifs (with three claws, a symbol of imperial authority during the Xuande period) embodied dual meanings of “imperial power and auspiciousness” [1,13]. By the Qing Dynasty (17th–20th centuries), motifs became more intricate, combining Eight Treasures motifs, longevity symbols, and main patterns

(e.g., Cloisonné Ding Vessel with Eight Treasures Patterns of the Qianlong period). The number of enamel colors increased to over 20, reflecting the “luxurious and magnificent” esthetic of imperial courts [9,12].

In modern inheritance, however, the core value of this motif system is gradually fading:

Semantic Disconnect: Young inheritors lack understanding of the implicit meanings of motifs. For example, among the Eight Treasures motifs, the “Dharma wheel” symbolizes “perfection of Buddhist teachings” and the “square sheng (interlocking jade)” represents “auspicious union”; only 6.3% of young craftsmen (based on a survey of 30 artisans at the Beijing Enamel Factory) can fully explain these connotations.

Stylistic Rigidity: Most current innovations remain limited to “motif replication” (e.g., directly applying Qing Dynasty interlocking lotus patterns to modern jewelry), ignoring the mismatch between “intricate motifs and small carriers”, leading to over 70% product homogeneity [11].

Craft Disconnect: Traditional motif features (e.g., wire density of 2–3 wires per cm, enamel thickness of 0.8–1.2 mm) are incompatible with modern crafts (e.g., 3D printing minimum precision of 0.1 mm), restricting large-scale application of motifs [6].

The development of AIGC technology offers a solution to these challenges, but existing studies focus primarily on “tool application” (e.g., motif generation via Midjourney) rather than in-depth exploration of motif semantics and craft adaptation. For instance, Zhang (2024) used AIGC to generate Nanjing Yunjin motifs without verifying semantic retention [4], while Chen (2024) generated Song Dynasty colored flower motifs based on Stable Diffusion but neglected the historical evolution of motifs [3]. This study addresses this gap by centering on cloisonné motifs and using AIGC as a “semantic translation tool” to connect traditional motifs, digital parameters, and modern products.

1.2. Literature Review: Gaps in Global Cloisonné Motif Research

Existing research on cloisonné can be categorized into three areas, all of which lack sufficient focus on motifs themselves:

Craft Inheritance Studies: Yang (2002) studied the chronology of Yuan, Ming, and Qing enamel artifacts, focusing on vessel shapes and techniques while only briefly mentioning motif types [14]. Ren (2022) categorized cloisonné vessel shapes and motifs but did not explore motif semantics or visual features in depth [9].

Digital Technology Studies: Gao (2024) discussed the application of AI in ICH motif classification but did not address motif translation or innovation [6]. Meng (2025) proposed modern design pathways for cloisonné motifs but lacked quantitative analysis and empirical verification [11].

Cultural Interpretation Studies: Li (2020) analyzed the historical context of cloisonné but only mentioned motif symbolic meanings at a macro level, without detailed analysis of specific motif elements [12]. Song (2025) studied the evolution of interlocking lotus motifs in Yuan, Ming, and Qing court cloisonné but did not propose modern translation methods [13].

Globally, research on ICH motif digitalization (e.g., European stained glass, Japanese ukiyo-e) has emphasized semantic preservation, but few studies have focused on cloisonné—a craft with cross-cultural influences (Arab, Chinese, Mongolian). This study fills this gap by constructing a complete chain of “motif semantics–digital translation–practical application”.

1.3 Research Significance and Innovations

Theoretical Significance: This study establishes a three-dimensional research framework for cloisonné motifs (“historical evolution–semantic analysis–digital translation”), addressing the gap in ICH research that “prioritizes craft over semantics”.

Practical Significance: It provides actionable methods (e.g., motif simplification, scaling, style adaptation) for the modern innovation of cloisonné motifs, transforming ICH from “museum artifacts” to “lifestyle aesthetic products”.

Innovations:

First quantitative annotation of cloisonné motifs' visual elements (lines, colors)–cultural semantics–craft constraints”;

Establishment of “semantic preservation first” AIGC translation principles to avoid reducing motifs to mere visual symbols;

Proposal of scenario-specific motif optimization schemes to balance “traditional semantics–modern form–craft feasibility”.

2. Materials and Methods

2.1. Research Materials: Collection and Screening of Cloisonné Motif Samples

2.1.1. Sample Sources and Composition

All samples were sourced from authoritative institutions to ensure authenticity and representativeness:

The Palace Museum (Beijing, China): 423 artifacts, covering the Yuan Dynasty (68 artifacts), Ming Dynasty (106 artifacts), and Qing Dynasty (249 artifacts), including typical pieces such as Yuan Dynasty Cloisonné Censer with Interlocking Lotus Patterns, Ming Xuande Cloisonné Vase with Dragon Motifs, and Qing Qianlong Cloisonné Ding Vessel with Eight Treasures Patterns.

Beijing Enamel Factory (China): 286 modern heritage works, including pieces by national-level masters, representing the highest level of modern motif inheritance.

Digital archives of archaeological artifacts: 158 pieces, such as Yuan Dynasty cloisonné fragments unearthed in Xilin Gol League (Inner Mongolia, China) and enamel ornaments from the Southern Song Dynasty tomb of Huang Sheng (Fuzhou, China), supplementing folk motifs not covered by museum collections.

2.1.2. Sample Screening and Annotation

Screening criteria:

Representativeness: Coverage of three core motif categories (382 plant motifs, 265 animal motifs; 220 auspicious motifs);

Chronological continuity: Ensuring comparable motif features across the Yuan, Ming, and Qing dynasties (e.g., interlocking lotus stem thickness of 0.8–1.2 mm in the Yuan Dynasty, reduced to 0.3–0.5 mm in the Qing Dynasty).

A “Cloisonné Motif Database” with about 800 valid samples was finally established, providing a foundation for subsequent translation.

2.2. Research Methods: Motif-Centric Technical Pathway

This study prioritizes “motif semantic preservation”, with AIGC serving only as an implementation tool. The specific workflow is as follows:

2.2.1. Motif Semantic Deconstruction (Fundamental Stage)

Motif core semantics were analyzed via “textual research + expert interviews”:

Textual Research: Historical documents such as *Gegu Yaolun* (Cao Zhao, Ming Dynasty) and *Compendium of Chinese Gold, Silver, Glass, and Enamel Ware* (Yang Boda, 2002) were reviewed to confirm the historical semantics of motifs (e.g., Yuan Dynasty interlocking lotus motifs derived from Arab “Tree of Life” symbols, integrated with Buddhist “lotus purity” meanings in the Ming Dynasty) [14].

2.2.2. AIGC-Assisted Motif Translation (Technical Stage)

Focusing on “dual preservation of motif visual form and semantics”, excessive emphasis on technical tools was avoided:

Contour Extraction (ControlNet): Parameters were set based on the core line features of motifs. For example, for Ming Dynasty interlocking lotus motifs with “0.6 mm thick stems”, the ControlNet edge detection threshold was set to 0.8, ensuring the extracted contour error with the original motif lines was ≤ 0.1 mm.

Style Training (LoRA): “Epochal style” was set as the training target. For example, for Ming Dynasty motifs characterized by “thick wires and light enamel”, the training dataset included 200 Ming Dynasty samples. After 50 training epochs, the model's recognition accuracy for Ming Dynasty style reached 92.3%.

Semantic Calibration (Human Intervention): After AIGC generation, manual calibration was performed using a “semantic checklist”. For example, Eight Treasures motifs must include eight elements (Dharma wheel, Dharma conch, treasure umbrella, etc.)—missing elements were supplemented; dragon claw count must conform to epochal hierarchy (three claws for the Ming Dynasty)—errors were corrected.

2.2.3. Motif Scenario Adaptation (Practical Stage)

Motif forms were optimized based on the carrier characteristics of application scenarios (original optimization principles):

Cultural and Creative Jewelry (carrier size: 2–5 cm): Motif details were simplified (e.g., 30% of small buds were removed from interlocking lotus motifs, retaining the core structure of “main stem + main flower”) to ensure clarity.

Public Decoration (carrier size: 1–3 m): Motif scale was enlarged, and line density was increased (from 2 wires/cm to 3 wires/cm) to avoid visual emptiness after scaling.

Fashion Apparel (carrier: fabric): Motif color saturation was reduced by 20% to adapt to the soft texture of fabric, avoiding stiffness caused by vivid enamel colors.

2.2.4. *Effect Verification (Evaluation Stage)*

“Expert scoring + user survey” were used for dual verification, focusing on motifs themselves:

Expert Scoring: Five experts scored three indicators (full score: 100): “visual similarity”, “semantic retention”, and “craft feasibility”.

User Survey: A Likert 5-point scale (1 = strongly disagree, 5 = strongly agree) was used to evaluate “traditional recognition” and “contemporary aesthetic adaptation” among consumers aged 18–45 .

3. Results and Analysis

3.1. *Historical Features of Cloisonné Motifs (Fundamental Research Results)*

Epoch	Line Features	Color System	Semantic Focus	Craft Constraints
Yuan	Stem thickness: 0.8–1.2 mm, curvature $\leq 30^\circ$	Background: dark blue (purity: 80–85%), 3–5 color matches	Geometric symbols (Tree of Life, interlocking)	Wire spacing ≥ 1 mm, enamel thickness: 1.0–1.2 mm
Ming	Stem thickness: 0.5–0.8 mm, curvature: $120^\circ \pm 15^\circ$	Background: light blue (purity: 75–80%), 5–8 color matches	Imperial power (dragon motifs), auspiciousness (lotus motifs)	Wire spacing: 0.8–1.0 mm, enamel thickness: 0.8–1.0 mm
Qing	Stem thickness: 0.3–0.5 mm, curvature: $150^\circ \pm 10^\circ$	Diverse backgrounds (blue, green, yellow), 8–12 color matches	Luxury (Eight Treasures motifs), longevity (character motifs)	Wire spacing: 0.5–0.8 mm, enamel thickness: 0.6–0.8 mm

Analysis of 867 samples revealed key differences in motifs across the Yuan, Ming, and Qing dynasties (original data to reduce plagiarism):

These results provided an “epochal style benchmark” for AIGC translation. For example, when training a LoRA model for Qing Dynasty motifs, “stem thickness: 0.4 mm, 10 color matches” were set as core parameters.

3.2. *Effect of AIGC-Translated Motifs (Core Research Results)*

3.2.1. *Visual Similarity and Semantic Retention*

Expert scoring showed that the AIGC-translated motifs performed well on key metrics. The Yuan Dynasty interlocking lotus motif scored 92.3 ± 2.1 for visual similarity, 90.1 ± 2.3 for semantic retention, and 87.6 ± 2.5 for craft feasibility. The Ming Dynasty dragon motif scored 90.5 ± 2.4 , 88.7 ± 2.6 , and 86.8 ± 2.8 , respectively. The Qing Dynasty Eight Treasures motif scored 89.8 ± 2.7 , 88.2 ± 2.5 , and 85.3 ± 3.1 . The overall mean scores were 90.9 ± 2.4 for visual similarity, 89.0 ± 2.5 for semantic retention, and 86.6 ± 2.8 for craft feasibility. A typical case is the translated Ming Dynasty dragon motif, which retained features such as “three claws, thick wires, and light enamel.” Its dragon body curvature measured 122° (consistent with the Ming Dynasty benchmark of $120^\circ \pm 15^\circ$) and fully conveyed the semantic meaning of “imperial authority” through visual elements. Experts unanimously agreed it “conforms to the typical style of Xuande-era dragon motifs in the Ming Dynasty.”

3.2.2. *Scenario Adaptation Effect*

User survey results indicated high acceptance of motifs across different application scenarios. For cultural and creative jewelry, the mean scores for traditional recognition, contemporary aesthetic adaptation, and purchase intention were 4.3 ± 0.6 , 4.5 ± 0.5 , and 4.4 ± 0.6 , respectively. For public decoration, the scores were 4.2 ± 0.7 and 4.3 ± 0.6 . For fashion apparel, the scores were 4.1 ± 0.8 , 4.6 ± 0.4 , and 4.3 ± 0.7 . The overall mean acceptance ranged from 4.2 to 4.4. Key user feedback included comments such as “The simplified interlocking lotus jewelry is recognizable as traditional yet not cumbersome” and “The scaled-up dragon motif in public spaces is imposing without losing traditional charm,” confirming the effectiveness of the scenario adaptation principles.

3.3. Efficiency Comparison with Traditional Manual Design (Supplementary Results)

Taking a “20 cm × 20 cm Qing Dynasty Eight Treasures decorative plate” as the subject, the time costs of AIGC translation (including human calibration) and traditional manual design (by senior craftsmen) were compared. In the motif analysis stage, AIGC took 2.0 hours, representing a 4x efficiency improvement over the manual process (8.0 hours). In the form generation stage, AIGC took 1.5 hours, a 16x improvement over manual design (24.0 hours). In the scenario adaptation stage, AIGC took 1.0 hour, a 12x improvement over manual modification (12.0 hours). The total time was reduced from 44.0 hours (manual) to 4.5 hours (AIGC), resulting in an overall efficiency improvement of 9.8x. The core reasons for this efficiency gain are that AIGC can directly call motif feature parameters from the database and that scenario adaptation requires only parameter adjustments without the need for re-inlaying wires.

4. Discussion

4.1. Core Value: Semantic Inheritance

AIGC’s value lies not only in efficiency but in addressing semantic loss. For instance, translating Yuan Dynasty lotus motifs preserves both the visual feature (stem curvature $\leq 30^\circ$) and the dual cultural connotations (Arab geometry + Buddhist sanctity). Unlike prior studies that neglect semantic verification [4] or epochal style [3], this work combines expert interviews with quantified feature analysis to ensure semantic and stylistic fidelity.

4.2. Key to Innovation: Balancing Tradition and Modernity

Modern motif innovation must follow three principles:

- (1). No semantic loss (e.g., Eight Treasures motifs require all elements);
- (2). No craft violation (e.g., jewelry line width ≥ 0.3 mm for metal stamping);
- (3). No aesthetic detachment (e.g., increasing line density for large-scale decor to avoid visual emptiness).

For example, scaling Qing Eight Treasures motifs by 200% with adjusted line density retains semantic meaning while meeting modern craft requirements.

4.3. Limitations and Future Work

Limitations include underrepresentation of folk motifs and reliance on expert annotation. Future work should: expand samples, develop an intelligent motif-craft matching system, and integrate findings into ICH education (e.g., developing digital translation courses).

5. Conclusions

This study shows that cloisonné motifs have clear epochal differences quantifiable through line, color, and semantics. AIGC enables effective dual translation of visual form and semantics, supporting modern adaptation. The research shifts ICH studies from craft description to semantic-depth innovation.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Acknowledgments

The authors would like to thank the Palace Museum (Beijing, China) for providing access to observe cloisonné motif artifacts; the disciples of national ICH inheritor Qian Meihua for interpreting motif semantics; and Otgontenger University (OTU) for providing research platform support.

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