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Research Article

Decoding Aesthetic Order and Authority in Hue Royal Court Furniture: A Quantitative Perspective

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Abstract: The art of Nguyễn Dynasty royal court furniture (1802–1945) is often described as a “wooden encyclopedia,” embodying strict rules of authority and aesthetics. However, existing scholarship has largely relied on qualitative interpretation, leaving the implicit rules that structure relationships among techniques, motifs, and colors as hypotheses in need of empirical testing. This paper proposes a quantitative approach to art-historical inquiry. Using an encoded dataset of 74 representative artifacts, the study applies statistical association measures (chi-square tests and Cramér’s V) alongside clustering analysis to examine the underlying aesthetic system. The results provide evidence of a strict “visual grammar,” including a strong preference for openwork carving in the depiction of authority (Cramér’s V > 0.6) and systematic principles of optical contrast within mother-of-pearl inlay. Overall, the study demonstrates how quantitative methods can function as a “data microscope,” offering a pathway toward more explicit and standardized heritage knowledge.

Keywords: Quantitative Analysis in Art History, Nguyen Dynasty Royal Furniture, Implicit Rules, Visual Grammar.

Highlights:

- Introduces a quantitative art history framework that integrates association metrics (chi-square tests, Cramér’s V) with historical cross-validation against documented classifications.
- Quantifies a strict “visual grammar” of authority, showing a strong preference for openwork carving in power symbolism (Cramér’s V > 0.6).
- Identifies a systematic optical-contrast principle, whereby mother-of-pearl inlay tends to avoid high-brilliance red/gold backgrounds.
- Demonstrates that social stratification is embedded in material culture, as unsupervised clustering recovers a hierarchy ranging from imperial ware to everyday utensils.

1. Introduction

1.1. Heritage as a Complex Aesthetic Encoding System

The royal furniture of the Nguyễn Dynasty (1802–1945) is more than a series of decorative or utilitarian objects. It constitutes a complex visual system that encodes the political, cultural, and philosophical ideologies of the imperial court. These objects, created through meticulous craftsmanship using materials such as red lacquer with gold gilding (son son thếp vàng), mother-of-pearl inlay (khảm trai), and symbolic carvings, serve

as “aesthetic texts” that reflect the Confucian-based order and governing philosophy of “ruling the country and pacifying the people” (trị quốc, bình dân) (Tieu, 2007; Tran, 2023). Each motif, color, and carved detail acts as a distinct semiotic unit within a codified artistic grammar intended to express social hierarchy, imperial legitimacy, and moral values (Safford, 2015; Dang, 2024).

Previous art historical research has identified key visual components in these royal furnishings, including motif systems such as the Four Sacred Animals (tứ linh) and the Eight Precious Objects (bát bửu), as well as color schemes involving red, gold, and black (De Hartingh & Craven-Smith-Milnes, 2012). However, while these elements are frequently described and categorized, the structural relationships between them have often remained intuitive rather than empirical (Nguyen & Sikka, 2023). Interpretations of motif placement and design hierarchy are frequently based on visual observation without the support of systematic quantitative analysis. These patterns are believed to have followed strict sumptuary regulations, although their logic has not been rigorously tested (Le & Thongkam, 2023).

1.2. The Gap between Perception and Quantitative Evidence

One of the major challenges in heritage and art research is the lack of methodology for transforming aesthetic perception into objective data. While descriptive and interpretive methods rooted in cultural theory provide valuable insights, they are often limited in confirming the presence of consistent visual rules or associations across collections (Safford, 2015). This methodological gap has prevented heritage studies from aligning with the empirical frameworks used in fields such as conservation science, cultural analytics, and digital humanities.

In the context of the Hue Imperial Palace, where many artworks are rich in symbolism and layered meaning, the absence of systematic measurement makes it difficult to verify hypotheses about visual hierarchy and encoded power structures (Tran, 2023). Without tools that can quantify relationships between motifs, techniques, and colors, the field remains restricted to qualitative insights, limiting the potential for interdisciplinary collaboration or standardized conservation protocols (Le, 2023).

1.3. A New Approach: Quantitative Analysis in Art History

To address this problem, this study proposes the use of quantitative structural analysis in the interpretation of Nguyễn Dynasty artifacts. Instead of relying on subjective observation, the research treats materials, motifs, and colors as variables within a structured dataset. The study aims to test the hypothesis that Nguyễn royal aesthetics are governed by statistically significant correlations that form a coherent visual grammar (Le Chung & Le, 2022; Dang, 2024).

This research focuses specifically on the Four Sacred Animals and the Eight Precious Objects, both of which were highly regulated within the visual repertoire of the Nguyễn court. These motifs were used to signal authority and rank, functioning as political iconography embedded in architectural and decorative forms (De Hartingh & Craven-Smith-Milnes, 2012). By analyzing their co-occurrence with specific techniques and color choices, the study aims to detect latent patterns that reflect dynastic ideology and stratification systems.

Through the application of correlation analysis and clustering methods, this research seeks to move beyond traditional descriptive frameworks. By transforming aesthetic attributes into analyzable data, the study contributes to the development of a more rigorous methodology for decoding historical visual systems in heritage contexts.

2. Methodology: Integrating Statistics, Art History, and Empirical History

The research establishes an interdisciplinary methodological framework, strictly integrating three pillars: Data Science to detect patterns, Empirical History to validate regulations, and Art Historical Analysis to decode formal principles.

2.1. Data Encoding based on Art Taxonomy

The first step is to convert the visual attributes of artifacts into digital data. The dataset comprises 74 representative wooden furniture artifacts selected through field surveys conducted in 2024 and 2025 at the Hue Monuments Complex, managed by the Hue Monuments Conservation Centre. The selection criteria focused on

artifacts that (1) have authenticated provenance as royal utensils used by the Emperor, mandarins, or the royal family; (2) represent the typical interior typology of the Nguyen Dynasty; and (3) satisfy physical conditions for 360-degree visual inspection.

Based on the principles of Art Historical Analysis, we established a standard taxonomy for three variable groups: Crafting Technique (Lacquer, Inlay, Carving...), Motif (Four Sacred Animals, Eight Precious Objects...), and Color.

Regarding the "Aesthetic Score" variable, to minimize subjective bias, we operationalized this metric using a 5-point Likert scale grounded in technical criteria:

- Low Aesthetic Value (Score 1–2): Assigned to artifacts with plain surfaces, basic structural joinery, and minimal decorative details (e.g., simple round tables).
- Medium Aesthetic Value (Score 3): Assigned to artifacts with standard relief carving or single-layer mother-of-pearl inlay, displaying moderate motif density.
- High Aesthetic Value (Score 4–5): Assigned to masterpieces featuring complex multi-technique integration (e.g., Openwork Carving combined with Gilding), high-resolution details, and multi-layered visual depth.

This quantitative scoring was performed by the author based on this fixed technical framework, ensuring consistency across the dataset. Subsequently, Binary Encoding (0/1) is applied to transform these observations into input data for computation. While we acknowledge that binary encoding may simplify the fluid nuances of artistic expression, it is a necessary abstraction to reveal macro-level systemic patterns. This process ensures that the digital data is not soulless but built upon a foundation of in-depth formal knowledge.

2.2. Theoretical Basis of the Quantitative Analysis Model

The research problem is translated into applying statistical models to measure the "signal strength" between aesthetic variables. The core mathematical toolkit used to decode these signals includes:

- Chi-squared Test (χ^2): Used as a statistical filter to determine whether the combination of a technique and a motif is random or intentional.
- Phi Coefficient (ϕ) and Cramér's V: Serve as quantitative metrics derived from the analysis to assess the strength of association. While χ^2 indicates that a relationship exists, ϕ and V indicate how strong that relationship is on a scale of 0 to 1, providing an objective quantitative index.
- Multivariate Clustering Analysis: An exploratory statistical technique used to group artifacts based on similarities in their multivariate "technical profiles." This method allows for the objective identification of typological groups (e.g., Imperial Ware vs. Common Ware) derived purely from data structure, minimizing subjective classification biases.

2.3. Hybrid Validation Loop

To ensure accuracy and eliminate statistical randomness, all statistical results must undergo a rigorous "double verification" step. Data correlations (e.g., technical conflicts) are compared with records in The Imperially Ordered Statutes and Regulations of Dai Nam (Khâm định Đại Nam hội điển sự lệ) and manual crafting technical principles and art historical documents. Only results that are consistent between data and historical materials are recognized as authentic aesthetic rules.

2.4. Research Execution Process with Quantitative Method as Core

The procedure is designed as a closed-loop model comprising four steps, ensuring that the output possesses both statistical significance and historical contextuality, with statistical algorithms playing the central role in data processing and exploration.

- Step 1: Feature Engineering – Digitizing Aesthetic Knowledge: This is the data preprocessing step, converting visual attributes into a binary structure. From 74 artifacts, attributes are encoded into binary data vectors (0/1) for variables including Technique, Motif, and Color. This encoding transforms each artifact into a data record, creating clean and standardized input material.
- Step 2: Data Mining & Pattern Recognition: Correlation analysis algorithms are employed on contingency tables to scan the entire dataset. The objective is to objectively detect hidden association rules, including pairs of variables that consistently co-occur (positive correlation) and

pairs that exclude one another (negative correlation or technical conflict). Results are visualized by analytical software using a heatmap to highlight aesthetic "hot spots" and "cold spots."

- Step 3: Stylistic Clustering – Identifying Trends: Unsupervised machine learning techniques are applied to group artifacts with similar technical profiles into clusters without human intervention or prior labeling. This step allows for the discovery of aesthetic schools or specific groups of imperial wares derived entirely from the data.
- Step 4: The Hybrid Validation Loop – Dialogue Between Quantitative Results and Experts: This is the pivotal step where the method transcends a purely statistical exercise. Discovered patterns (e.g., the conflict between mother-of-pearl inlay and openwork carving) are subjected to the validation loop. Here, they are cross-referenced and evaluated based on (1) crafting regulations in historical documents (The Imperially Ordered Statutes and Regulations of Dai Nam), (2) technical principles and physical properties of materials, and (3) Confucian ideology regarding hierarchy and order. Only results that pass this rigorous hybrid validation are recognized as the dynasty's aesthetic rules. This process ensures quantitative analysis acts as a powerful discovery tool, while the researcher retains the role of final adjudication and interpretation based on specialized knowledge.

3. Results

3.1. Technical Polarization and Symbols of Authority

The results of scanning the encoded data from 74 artifacts have provided verifiable digital evidence, illuminating the implicit rules governing the relationship between crafting techniques and decorative motifs. The figures from the correlation matrix are not merely statistical values; they paint a clear picture of the stratification and specialization within the Nguyen Dynasty royal workshops (Figure 1).

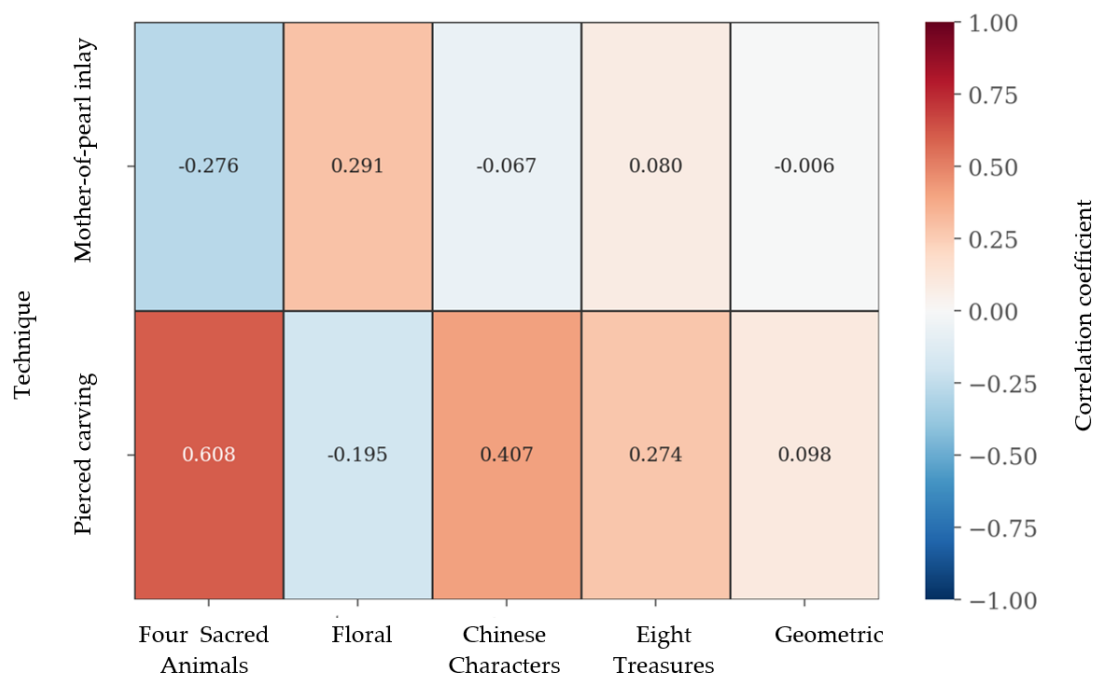


Figure 1. Heatmap Matrix displaying the correlation coefficients between Technique and Motif. The color gradient from blue to red corresponds to weak to strong correlations (Source: Author).

3.1.1. Findings on Correlations

Openwork Carving and Four Sacred Animals ($\varphi = 0.608$): This is the strongest positive correlation detected by statistical test results. It confirms an implicit rule regarding Openwork Carving—a pinnacle technique for

creating space and volume—which was absolutely prioritized by ancient artisans to depict the Four Sacred Animals motif group (Dragon, Unicorn, Turtle, Phoenix). Data indicates that this combination is intentional, allowing light to penetrate and creating real depth rather than simulated depth, resulting in vivid volumetric effects that highlight the majesty and sacredness of these symbols.

Openwork Carving and Han Characters ($\varphi = 0.407$): Results also point to a moderate positive correlation, indicating that Openwork Carving is a preferred technique for rendering textual motifs. The depth and fluidity of lines inherent in this technique allow for the subtle expression of variations in Han characters within different compositions.

Mother-of-pearl Inlay and Four Sacred Animals ($\varphi = -0.276$): Another significant finding is this negative correlation. It demonstrates that Mother-of-pearl Inlay and Openwork Carving are nearly mutually exclusive technical choices for the same Four Sacred Animals motif group. While Openwork Carving honors volume, Mother-of-pearl Inlay honors the surface and reflective light effects.

Mother-of-pearl Inlay and Flora ($\varphi = 0.291$): In contrast to the Four Sacred Animals, results show that Mother-of-pearl Inlay tends to be combined with Flora. The sparkling, iridescent quality of mother-of-pearl is confirmed by quantitative data as being highly suitable for simulating the brightness and liveliness of nature.

3.1.2. Verification from Art History and History

When subjecting the above findings to the Hybrid Validation Loop, a distinct alignment with historical and artistic knowledge was discovered:

- From an Art History perspective: The sacred beasts in the Four Sacred Animals set, particularly the Dragon, require majesty and dynamic form. Only Openwork Carving—a technique for processing three-dimensional space for decorative designs—is capable of rendering the spirit and volume of this sacred creature in space.
- From a Crafting Technique perspective: Combining Mother-of-pearl Inlay and Openwork Carving on the same motif was extremely difficult, if not technically impossible in that historical context, due to completely different physical properties and fabrication processes. The finding of the negative correlation by quantitative analysis has successfully quantified this practical experience of the artisans.
- Thus, by scrutinizing micro-data, the study has confirmed a strict "visual grammar": to express authority for the Four Sacred Animals, Openwork Carving is used to honor volume. To express the naturalness of flora and nature, Mother-of-pearl Inlay is applied as a method to honor both the subject matter and the original material.

3.2. Decoding the Intentional Relationship between Technique and Color

Next, the model aimed to decode the relationship between technique and color, discovering subtle color coordination principles (Figure 2).

3.2.1. Findings on the Contrast between Reflective Light and Background

- Mother-of-pearl Inlay and Gold, Red Colors ($\varphi \sim -0.45$): The analysis indicates a strong negative correlation, proving that Mother-of-pearl Inlay rarely appears on brilliant red lacquer and gilded backgrounds.
- Mother-of-pearl Inlay and Brown Color ($\varphi = 0.439$): Demonstrates a strong positive correlation with dark color groups, such as the brown of rosewood or ebony. This indicates a deliberate selection between these color groups within the same surface finishing technique.

3.2.2. Verification from the Hybrid Loop Regarding Optics and Visual Effects

The results from quantitative analysis are entirely consistent with perspectives from Art History verification and material-technical engineering. Quantitative metrics effectively detected optical laws within the crafting process. Mother-of-pearl material inherently possesses a subtle iridescence. If placed on a brilliant red lacquer and gilded background, the mother-of-pearl's shimmer would be visually overwhelmed. Therefore,

a dark brown precious wood background or black lacquer creating high contrast is a prerequisite condition to honor the sparkle and elegance of the material.

Regarding Openwork Carving and color, the data records a simultaneous state of saturation, with no outstanding cases. This result aligns with art historical verification, confirming that the value of Openwork Carving lies in the penetration of light through carved layers and 3D volumes, rather than depending on the color of the surface coating. Consequently, this technique can adapt flexibly to all colors and is not bound by tonal intensity.

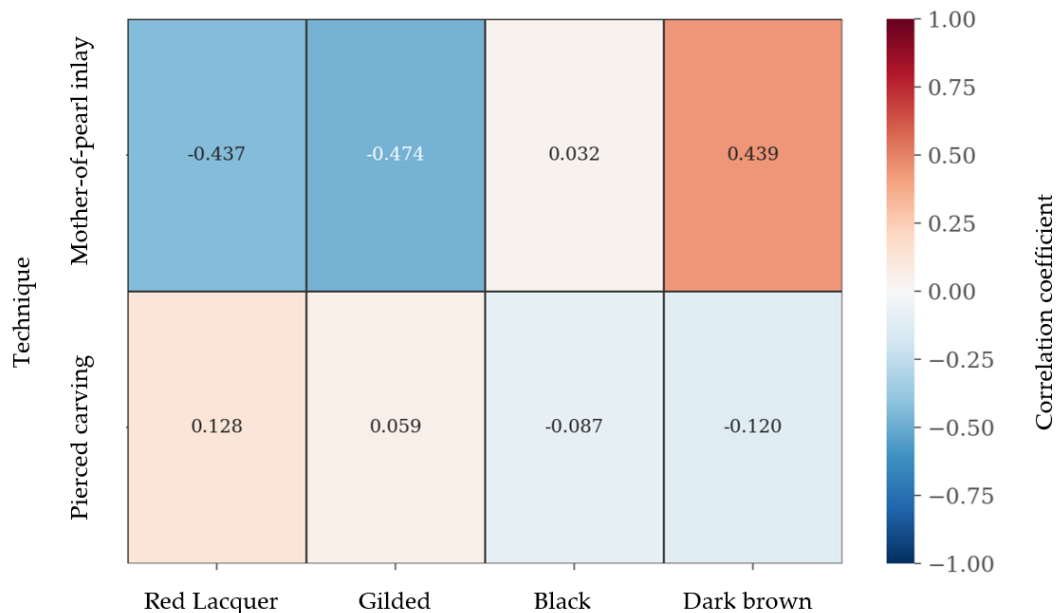


Figure 2. Heatmap Matrix displaying the correlation coefficients between Technique and Color (Source: Author).

3.3. Multivariate Analysis - Aesthetic Resonance with Technical Combinations

3.3.1. Quantitative Analysis of "Aesthetic Resonance" Laws

Looking at the main correlation matrix in Figure 3, the model established a significant finding: a strong positive correlation between Technique Count and Aesthetic Score ($\varphi = 0.57$). This suggests that the aesthetic value of a masterpiece does not lie in a single technique, but in the seamless, calculated combination of multiple techniques to create an effect of aesthetic resonance. From a data perspective, artifacts with the highest aesthetic scores never appear as single-technique items. They are always a combination of at least 2–3 techniques. Quantitative analysis has demonstrated that this complexity and layering directly correlate with value acknowledged in scientific research. Art Historical verification of this finding asserts that the value of imperial ware lies not only in precious materials but also in the labor time and the masterful coordination level of the artisans. The Nguyen Dynasty clearly exalted the beauty of complexity and labor-intensiveness within material layers crafted exquisitely through multiple processing stages.

3.3.2. Quantitative Analysis Confirming the Pivotal Role of "Pinnacle" Techniques

Within the same matrix, analysis results also indicated a strong correlation between Openwork Carving and Aesthetic Score ($\varphi = 0.51$). This indicates the status of Openwork Carving as a pivotal technique, a paramount "indicator" for assessing the aesthetic value of an artifact. The presence of this technique is strongly associated with high-value artistic masterpieces.

3.3.3. Identifying Social Stratification through "Technical Profiles"

Applying Unsupervised Learning algorithms to the same dataset divided the 74 artifacts into 4 distinct clusters based on similarities in their "technical profiles," without any human intervention. This Clustering result (Figure 3) is evidence of the ability to detect social structures encoded within technical characteristics.

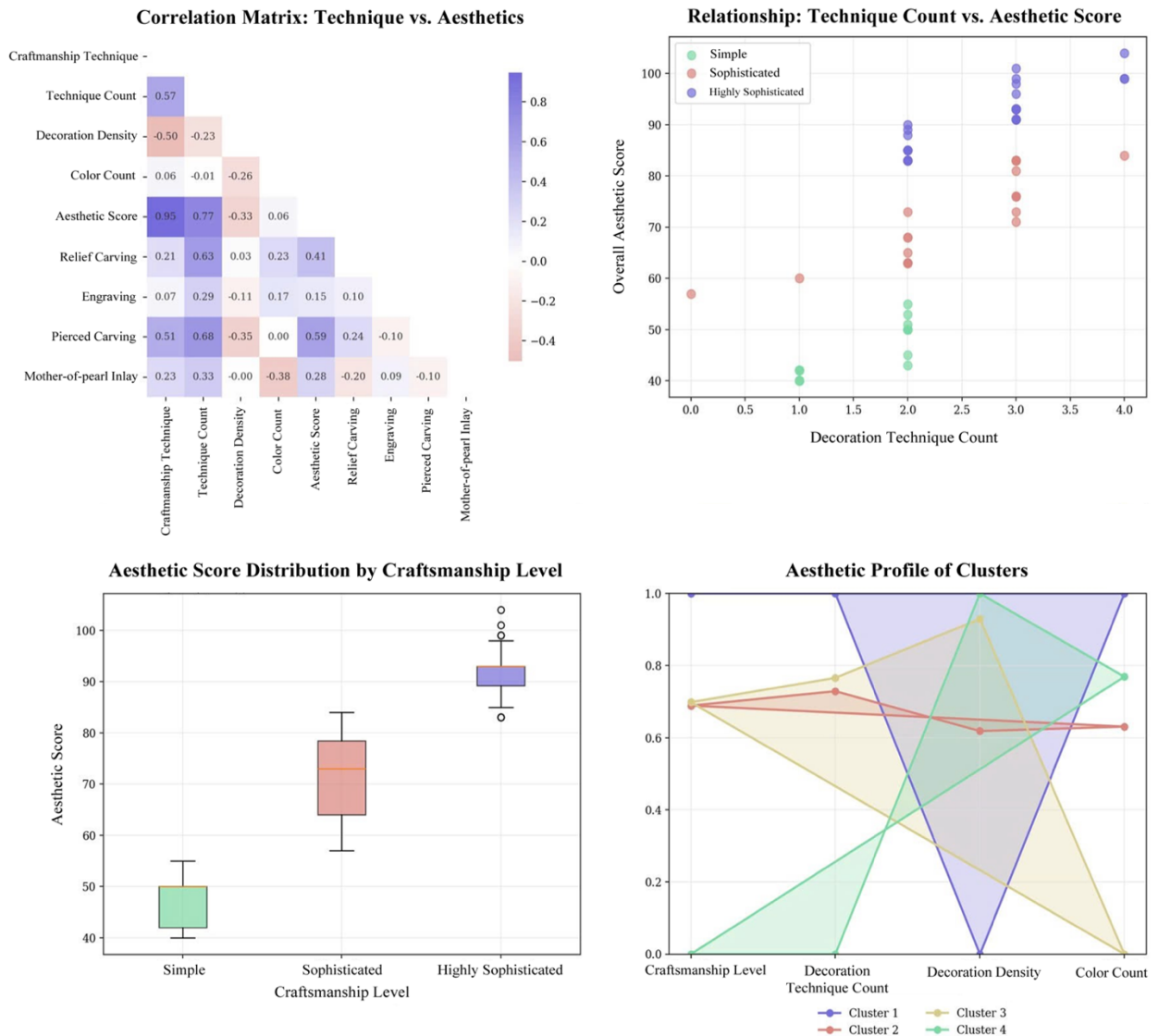


Figure 3. Multivariate Analysis between Craftsmanship Techniques and Aesthetics (Source: Author)

- Cluster 1 (The Highly Sophisticated Group): Results identify this as a group of artifacts with very high aesthetic scores (> 90), employing the most complex techniques such as Openwork Carving and Red Lacquer Gilding.
- Historical Cross-Reference: This is precisely the group of Imperial Ware (Đồ ngự dụng), including Thrones and Royal Beds—objects symbolizing the supreme power of the King.
- Cluster 4 (The Simple Group): Determined as a group of artifacts with few techniques, primarily plain wood or light carving.
- Historical Cross-Reference: This group corresponds to Daily Utensils or items for lower ranks within the palace, where practicality was prioritized.

Thus, integrating Multivariate Analysis and Clustering has demonstrated three key arguments: (1) Aesthetic value is constructed by the resonance of multiple techniques; (2) Openwork Carving plays the role of an important "power indicator"; and (3) the stratified social structure of the court is faithfully reflected and measurable through the "technical profiles" of artifacts. Consequently, after verification through Art History and Empirical History,

the composite charts show that quantitative analysis truly functions as a "data microscope," not only seeing individual correlations but also connecting them to expose an entire system of aesthetic logic and complex social order.

4. Discussion

4.1. Quantitative Research - A New Prism for Heritage

This study demonstrates that multivariate correlation analysis is not simply a supporting tool but a transformative methodological lens for decoding the complex visual systems embedded in cultural heritage. In the context of the Nguyen Dynasty, where visual form was inseparable from imperial ideology, the use of data-driven methods enables a deeper understanding of how material, technique, motif, and color were orchestrated into coherent visual languages (Tran, 2023).

By translating visual attributes into verifiable data, the research moves beyond speculative interpretation toward an empirical framework. Correlation matrices and clustering models illuminate systemic aesthetic patterns, such as the deliberate exclusivity between mother-of-pearl inlay and red lacquer—a relationship previously recognized anecdotally by conservators but now statistically confirmed (Nguyen et al., 2025). This represents a breakthrough in identifying the hidden logic behind craft choices, where artisanal intuition regarding light reflectivity, material compatibility, and symbolic intent can now be measured and reproduced through data.

The findings also highlight the capacity of quantitative models to uncover nuanced relationships that elude traditional methods. For instance, the strong positive correlation between Openwork Carving and Four Sacred Animals reveals how technical mastery was reserved for motifs signifying imperial authority. Similarly, the clustering of artifacts into clearly stratified groups—ranging from highly sophisticated imperial ware to minimally decorated daily items—reflects the socio-political structure encoded within decorative practices (Nguyen & Sikka, 2023; Tran, 2023). These patterns are not only statistically evident but historically validated, aligning with archival crafting rules and visual principles from court regulations.

Most notably, this research quantifies aesthetic value itself. The correlation between Technique Count and Aesthetic Score ($\varphi = 0.57$) confirms that complexity—rather than minimalism—was the dominant aesthetic logic of Hue's royal workshops. The more techniques applied, the higher the perceived aesthetic resonance, especially when executed in coordinated combinations. This insight aligns with traditional Vietnamese conceptions of layered beauty and craftsmanship depth, now reinforced by empirical modeling (Le & Kelboro, 2019).

In essence, quantitative heritage research offers three major contributions: it introduces objectivity into aesthetic analysis, enables the processing of complex design systems, and produces measurable evidence to validate long-standing art historical hypotheses. This paradigm shift holds promise not only for Vietnamese imperial studies but also for the broader field of digital heritage. Rather than displacing traditional humanities methods, it enhances them—functioning as a "data microscope" that reveals the structural logic behind visible forms.

4.2. Limitation

Although this study introduces a new methodological approach to analyzing Nguyen Dynasty royal furniture through quantitative techniques, several limitations should be acknowledged.

First, the dataset was limited to 74 artifacts, selected based on availability, visual clarity, and physical preservation. While these artifacts are representative of key typologies, the sample size remains relatively small and may not capture the full range of stylistic diversity or regional variation across the dynasty. Future research should expand the dataset to include a broader spectrum of objects and utilize digitization tools to incorporate partially damaged or fragmented pieces.

Second, the process of data encoding required the translation of complex visual attributes into simplified categories. Binary classification, although necessary for statistical analysis, may overlook subtle gradations and aesthetic nuances that are essential to traditional craftsmanship. While efforts were made to minimize subjectivity through structured criteria, certain aspects of aesthetic scoring inevitably involve interpretive judgment.

Third, the focus of the study was limited to specific decorative groups and formal elements, such as the Four Sacred Animals and Openwork Carving. Other relevant iconographic systems, including narrative illustrations,

poetic inscriptions, and foreign artistic influences, were not addressed and remain valuable areas for future exploration.

Finally, while statistical tools offer a powerful means of identifying patterns and associations, they cannot fully account for the symbolic, philosophical, or ritual meanings embedded in heritage artifacts. Interpretation still relies on contextual knowledge from art historians, cultural experts, and archival sources. Therefore, this study positions quantitative analysis as a complementary tool rather than a substitute for qualitative and interpretive methodologies.

5. Conclusion and Recommendations

This research affirms that quantitative analysis, when grounded in historical understanding and aesthetic insight, provides a powerful tool for studying cultural heritage. It does not aim to replace the nuanced perceptions of art historians or the intuitive knowledge of traditional craftsmen. Instead, it positions data analysis as a collaborative partner—capable of revealing structural relationships and systemic patterns that are otherwise difficult to perceive.

Through the application of correlation analysis and clustering techniques to the visual elements of Nguyen Dynasty royal furniture, the study identifies a consistent aesthetic logic embedded in materials, techniques, and motifs. These findings support the idea that heritage objects carry more than symbolic meaning; they also embody encoded rules that reflect philosophical, social, and technical systems of their time. The ability to quantify these aesthetic choices provides a new methodological foundation for heritage studies, making it possible to evaluate design decisions with scientific precision while respecting their cultural depth.

Quantitative methods in heritage research offer three key contributions. First, they enable objectivity in detecting and verifying artistic patterns. Second, they reveal complex relationships among multiple variables that are not easily observed through traditional analysis. Third, they introduce a scalable approach for interpreting heritage across disciplines, bridging the gap between the humanities and data science.

To extend this research approach and ensure its meaningful application, the following recommendations are proposed:

- Develop digital infrastructure for heritage collections by creating standardized and accessible databases that encode key visual and material attributes.
- Create specialized digital tools tailored to heritage research, including automated systems for motif recognition and statistical pattern detection.
- Encourage interdisciplinary collaboration between data scientists and heritage scholars to co-design research frameworks that respect both technical rigor and cultural context.
- Establish new academic standards for publishing and evaluating research that integrates computational methods, ensuring that such work is assessed with both disciplinary and technical expertise.

Quantitative analysis should be regarded as a companion to human insight. It enhances our ability to perceive and interpret the richness of the past by transforming aesthetics into analyzable structure. With this expanded methodological lens, scholars can more effectively protect, understand, and share the cultural knowledge embedded in material heritage.

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