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A Framework for Translating and Reconstructing Regional Textile Cultural Elements in Interior Environmental Design

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ABSTRACT

Regional textile culture contains visual, structural, and symbolic features that can inform contemporary interior environmental design. However, such elements are often used through superficial decorative borrowing, which weakens cultural depth and spatial coherence. To address this issue, this study proposes a structured framework for translating and reconstructing regional textile cultural elements in interior design. The framework includes four stages: cultural element decomposition, feature-based translation, spatial reconstruction, and multi-criteria evaluation. A case study based on traditional Chinese embroidery was conducted to test the framework. Textile samples were analyzed from visual, structural, and semantic perspectives and translated into spatial components through predefined mapping rules. The resulting design schemes were evaluated using an AHP- and fuzzy-based weighted method. The results show that the framework improves overall design performance, with significant improvements in cultural expression and spatial coherence, while improvements in aesthetic quality and functional performance remain comparatively moderate. Sensitivity analysis further confirms the relative stability of the evaluation results. Overall, the study provides a structured methodological basis for integrating regional textile culture into contemporary interior environmental design.

KEYWORDS

regional textile culture, interior environmental design, cultural element translation, spatial reconstruction, multi-criteria evaluation

INTRODUCTION

Regional textile culture, including traditional embroidery, weaving, and dyeing practices, constitutes an important component of cultural heritage, visual identity, and regional aesthetic memory. These textile traditions embody not only distinctive decorative motifs and color systems, but also structural logic, symbolic associations, and craft knowledge accumulated through long-term historical development. In contemporary

design discourse, such cultural elements are increasingly regarded as valuable resources for promoting cultural sustainability, reinforcing place identity, and enhancing the experiential quality of built environments [1]. Against this background, the incorporation of traditional textile culture into interior environmental design has attracted growing scholarly and practical attention [2,3].

Despite this growing interest, the application of regional textile cultural elements in interior design is still frequently limited to surface-level visual borrowing or direct pattern transplantation. In many cases, textile motifs are used mainly as decorative references, while the deeper structural order, semantic content, and cultural context embedded in the original textile forms are insufficiently interpreted [4,5]. As a result, the design outcomes may appear visually recognizable yet conceptually shallow, making it difficult to establish a coherent relationship between cultural source materials and contemporary spatial expression. This problem becomes more evident in modern interior environments, where cultural representation must not only be visible, but also adaptable to functional requirements, formal restraint, and spatial continuity. Therefore, the lack of a systematic method for translating regional textile culture into spatial design language remains a significant limitation.

Existing studies have explored the integration of cultural elements into design from several perspectives. First, from the viewpoint of design theory, previous research has emphasized structured design thinking, semantic interpretation, and process-oriented approaches as important means of improving design consistency and innovation [4,6]. These studies provide a conceptual basis for understanding how cultural content may be transformed into contemporary design knowledge. However, many of them remain at the level of general methodology and do not sufficiently address how specific cultural materials, especially textile-based visual systems, can be converted into spatial design outputs in a reproducible manner.

Second, in the field of cultural heritage and digital design, increasing attention has been paid to knowledge-based representation, semantic systems, and digital documentation of traditional cultural resources [7-9]. These approaches have contributed to the preservation and reinterpretation of heritage information, and they demonstrate the value of building structured relationships between cultural content and design application. Nevertheless, in many cases, these studies emphasize documentation, visualization, or knowledge organization rather than direct translation into interior environmental design. As a result, the connection between cultural analysis and spatial implementation remains relatively weak.

Third, recent advancements in computer vision, image analysis, and pattern recognition have provided technical support for the extraction and classification of visual features from textile patterns and decorative systems [10]. These studies show that textile elements can be partially analyzed in terms of colors, motifs, and compositional regularity, thereby offering a more objective basis for design interpretation. At the same time, studies on spatial perception, architectural elements, and visual evaluation have further suggested that semantic, visual, and structural information should be considered together in the assessment of built environments [11-14]. However, most existing work focuses on isolated tasks, such as feature extraction, visual assessment, or user perception, rather than establishing an integrated framework that links cultural decomposition, design translation, spatial reconstruction, and performance evaluation.

In addition, although quantitative and semi-quantitative methods such as the analytic hierarchy process (AHP) and fuzzy set theory have been widely applied in design assessment, they are often introduced only at the final evaluation stage rather than being embedded within the overall design process [15,16]. This separation weakens the methodological continuity between design generation and design evaluation. In other words, cultural analysis, spatial transformation, and performance assessment are frequently treated as independent steps rather than components of a unified framework. This fragmentation reduces the interpretability, comparability, and reproducibility of culturally oriented design research.

Based on the above observations, the main research gap can be summarized in three aspects. First, there is still a lack of a structured method for decomposing regional textile cultural elements into analyzable design information. Second, the translation relationship between textile features and spatial design components remains insufficiently formalized. Third, a relatively complete framework that integrates cultural analysis, spatial reconstruction, and quantitative evaluation has not yet been adequately established for interior environmental design. These limitations indicate the need for a more systematic and multi-layered methodological approach.

To address these issues, this study proposes a structured framework for translating and reconstructing regional textile cultural elements in interior environmental design. The proposed framework integrates four key stages: cultural element decomposition, feature-based translation, spatial reconstruction, and multi-criteria evaluation. Rather than treating textile culture as a source of isolated visual ornament, the framework aims to convert it into a structured set of design inputs that can guide spatial generation and comparative assessment.

In this way, the study attempts to establish a clearer methodological link between cultural heritage resources and contemporary interior design practice.

The contributions of this study are threefold. First, a multi-layer decomposition method is developed to systematically analyze regional textile cultural elements from visual, structural, and semantic perspectives. Second, a set of rule-based translation and reconstruction strategies is proposed to map these elements into spatial design components in a coherent, controllable, and adaptable manner. Third, a multi-criteria evaluation model is introduced to quantitatively compare alternative design schemes in terms of cultural expression, aesthetic quality, functional performance, and spatial coherence. Through these contributions, the study seeks to provide a more transparent and reproducible methodological basis for culturally driven interior design research and practice.

METHODOLOGY

Overall Framework

To ensure a systematic and reproducible design process, this study proposes a structured framework for translating and reconstructing regional textile cultural elements into interior environmental design. The framework consists of four sequential stages: (1) cultural element decomposition, (2) feature-based translation, (3) spatial reconstruction, and (4) multi-criteria evaluation, as illustrated in Figure 1.

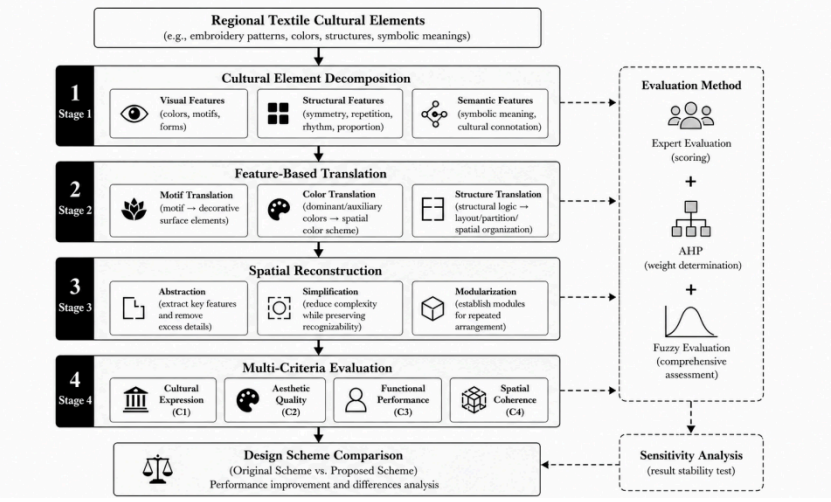

Figure 1. Structured framework for translating and reconstructing regional textile cultural elements in interior environmental design

Unlike conventional design approaches that rely heavily on subjective interpretation, the proposed framework organizes the transformation process into a step-by-step pipeline, allowing each stage to be explicitly defined

and independently analyzed. This structured organization improves the transparency of the design process and facilitates reproducibility in different application contexts [2,7].

In addition, the framework integrates both qualitative interpretation and semi-quantitative analysis. While cultural meanings are interpreted through semantic analysis, visual and structural features are extracted and mapped using rule-based strategies. This hybrid approach avoids over-reliance on purely subjective judgment while maintaining flexibility in design representation. Such a balance is essential in cultural design studies, where complete quantification may not be feasible but systematic structuring is required [4,8].

More specifically, the framework is intended to establish a logical connection between cultural resources and spatial design outputs. Instead of treating textile culture as a decorative reference only, the proposed approach translates it into analyzable design information and then reconstructs it into a spatial system. This process improves methodological rigor and provides a clearer basis for subsequent evaluation and comparison.

Cultural Element Decomposition

To enable systematic translation, regional textile cultural elements are first decomposed into three hierarchical layers: visual, structural, and semantic components. This multi-layer decomposition ensures that both observable features and implicit cultural meanings are considered during the design process.

The visual layer includes directly perceivable attributes such as color schemes, pattern motifs, and geometric compositions. These elements are typically extracted through visual inspection supported by basic image analysis, such as identifying dominant colors and repeating patterns [10,17]. The structural layer refers to the organizational logic of textile patterns, including repetition, symmetry, and rhythm, which can be interpreted as spatial ordering principles in interior design. The semantic layer captures the symbolic meanings and cultural narratives embedded in textile elements, which are identified through literature references and expert interpretation [4,5].

It should be noted that the decomposition process does not aim to achieve fully automated feature extraction. Instead, a semi-structured approach is adopted, combining manual annotation with rule-based classification. This choice is made to ensure interpretability and feasibility, especially when dealing with culturally rich but heterogeneous data sources. Such an approach has been widely adopted in cultural design studies where purely data-driven methods may lack contextual accuracy [7]. The classification of these textile cultural elements is summarized in Table 1.

Table 1. Classification of textile cultural elements

Layer	Description	Examples
Visual	Observable features such as colors and motifs	Floral patterns, color palettes
Structural	Organizational logic of patterns	Symmetry, repetition, rhythm
Semantic	Cultural meanings and symbolic expressions	Cultural symbols, traditional meanings

Translation Mechanism

Based on the decomposed cultural elements, a feature-based translation mechanism is established to map textile characteristics into spatial design components. The translation process follows a set of predefined mapping rules that connect textile features with corresponding interior design elements.

Specifically, pattern motifs in the visual layer are translated into surface treatments such as wall decorations, flooring patterns, or partition elements. Color features are mapped to interior color schemes, including dominant tones and accent colors. Structural characteristics, such as repetition and symmetry, are interpreted as spatial organization strategies, influencing layout rhythm and modular arrangements [18].

This mapping process can be conceptually expressed as:

$$D = f(V, S, M) \tag{1}$$

where D represents the spatial design output, V denotes visual features, S represents structural features, and M refers to semantic features. In this study, the function f is not treated as a strictly numerical function, but as a rule-based mapping mechanism in which each feature category is associated with predefined spatial design elements. In other words, the proposed formulation serves as a conceptual representation of the translation logic rather than a fully computational model. For example, visual motifs are mapped to decorative surfaces, structural characteristics are transformed into layout logic, and semantic features guide the thematic orientation of the design scheme.

To make the translation process more explicit, the mapping rules are implemented as predefined correspondences rather than arbitrary design decisions. For instance, floral and symbolic motifs are preferentially assigned to visually prominent surfaces such as walls or partitions, repetitive geometric features are translated into flooring or modular spatial arrangements, and culturally meaningful semantic elements are retained in

thematic or symbolic design components. This rule-based implementation improves the consistency of the transformation process and allows different design schemes to be compared under the same mapping logic. To avoid excessive abstraction or arbitrary transformation, the mapping rules are defined based on design precedents and consistency principles. Each rule is applied consistently across the case study to ensure comparability. Although the mapping process still involves certain design decisions, the use of explicit correspondences reduces randomness and improves methodological clarity [2,10].

Furthermore, the translation process is not intended to directly replicate textile forms in space. Instead, it emphasizes adaptive transformation. In this way, regional textile culture is preserved at the level of design logic and cultural meaning, while the resulting spatial form remains suitable for contemporary interior application.

Reconstruction Strategy

Following the translation stage, the reconstructed design is generated through a structured spatial adaptation process. The reconstruction strategy is guided by three principles: abstraction, simplification, and modularization.

First, abstraction is applied to extract essential features from complex textile patterns while removing unnecessary details. This step ensures that the design remains adaptable to different spatial scales and avoids excessive visual density. Second, simplification is used to reduce formal complexity and improve compatibility with contemporary interior environments. This is particularly important because direct transplantation of highly intricate textile patterns may lead to visual overload or reduced spatial clarity. Third, modularization is adopted to transform textile elements into repeatable spatial units, enabling flexible arrangement, consistency, and scalability in interior design [18].

The reconstruction process is implemented through iterative refinement rather than a single-step transformation. At each iteration, the design is reviewed against predefined criteria to ensure that both cultural representation and spatial functionality are maintained. This iterative approach improves the robustness of the final design outcome and reduces the risk of overfitting to a single interpretation.

From a practical perspective, the reconstruction strategy aims to preserve cultural recognizability while ensuring design feasibility. Therefore, the final scheme is not judged solely by the degree of cultural retention, but also by its adaptability to interior use conditions, including visual coherence, spatial usability, and compositional balance.

Evaluation Method

To quantitatively assess the effectiveness of the proposed framework, a multi-criteria evaluation method is adopted. The evaluation system includes four indicators: cultural expression, aesthetic quality, functional performance, and spatial coherence.

A weighted scoring approach based on the analytic hierarchy process (AHP) is used to determine the relative importance of each indicator [15]. The weights are derived from expert judgment, and consistency checks based on the consistency ratio (CR) were applied to ensure the reliability of the pairwise comparison matrix. The CR value was calculated using the eigenvalue method, where $CR = CI/RI$ and $CI = (\lambda_{max} - n)/(n-1)$. The obtained CR value was 0.06, which is below the acceptable threshold of 0.10, indicating that the expert judgments were sufficiently consistent and that the derived weights were reliable. To account for uncertainty in subjective evaluation, fuzzy set theory is incorporated to handle variations in expert scoring [16].

It should be noted that the evaluation model is not intended to produce absolute performance values but rather to enable relative comparison between different design schemes. Therefore, moderate variability in scoring results is expected and considered acceptable. This approach avoids overly idealized or uniform results and better reflects real-world evaluation conditions. To further enhance the credibility of the assessment, the weighting process is used only to establish the relative importance of criteria, and the final ranking is further examined through sensitivity analysis in Section 4.3. The evaluation criteria and their corresponding weights are summarized in Table 2.

Table 2. Evaluation criteria and weights

Criteria	Description	Weight
Cultural Expression	Degree of cultural representation	0.35
Aesthetic Quality	Visual attractiveness and harmony	0.25
Functional Performance	Usability and spatial functionality	0.20
Spatial Coherence	Consistency of spatial organization	0.20

To improve the reliability of the evaluation, the scoring process is based on expert assessment rather than single-author judgment. A standardized evaluation sheet is provided to all experts so that each scheme can be scored independently according to the same criteria and scoring scale. Each criterion is then aggregated according to the assigned weights. In this way, the evaluation framework provides not only a comparative

basis for judging design quality, but also a structured mechanism for identifying the relative strengths and limitations of each scheme.

Although the number of experts involved in the evaluation is relatively limited, the use of standardized scoring procedures and sensitivity analysis helps enhance the reliability and robustness of the evaluation results.

CASE STUDY

Case Selection and Data Preparation

To validate the effectiveness of the proposed framework, a case study based on Suzhou embroidery-inspired textile samples was conducted. Suzhou embroidery was selected because of its refined floral motifs, balanced composition, delicate color transitions, and strong decorative-symbolic characteristics, which make it suitable for visual, structural, and semantic decomposition. Compared with some other traditional textile categories, Suzhou embroidery patterns typically present clearer visual boundaries, stronger ornamental characteristics, and more explicit cultural symbolism, which facilitates decomposition, mapping, and reconstruction within the proposed framework. A set of representative Suzhou embroidery-inspired samples was collected from publicly accessible design archives, museum collections, and literature sources. The selected samples include floral motifs, geometric arrangements, and symbolic decorative patterns that are frequently observed in Suzhou embroidery. To avoid excessive homogeneity, the sample set is intentionally selected to cover different types of visual composition, including centralized motifs, repetitive units, and border-like arrangements. This diversity helps test whether the proposed framework can accommodate varying textile characteristics rather than being limited to a single decorative form. Although Suzhou embroidery was used as the case source in this study, the proposed framework is not limited to this single embroidery tradition. Other regional embroidery traditions, such as Hunan, Guangdong, or Sichuan embroidery, may require adjusted mapping rules according to their specific motifs, colors, structures, and cultural meanings.

The target application scenario is defined as a contemporary interior environment, including wall surfaces, flooring patterns, and semi-open partition elements. These design components are selected because they provide sufficient spatial surfaces for cultural translation while also representing common interior applications. To ensure comparability, all design transformations are conducted under the same spatial constraints, including a consistent layout setting, similar functional assumptions, and comparable material conditions. This controlled setting reduces external interference and helps ensure that the observed differences between design schemes are mainly associated with the translation and reconstruction strategy.

In order to support subsequent evaluation, the final design schemes are assessed by a panel of five experts with backgrounds in interior design, textile design, or design theory. Each expert independently scores the schemes according to the criteria defined in Section 2.5. The final reported values are presented as mean scores with standard deviations, thereby reflecting both the central tendency and moderate variation in expert judgment. This setup improves the credibility of the evaluation and reduces the influence of individual preference. Although the number of experts involved in the evaluation is relatively limited, the use of standardized scoring procedures and sensitivity analysis helps enhance the reliability and robustness of the evaluation results. Five experts participated in the evaluation, including two interior design researchers, one textile design researcher, one cultural design practitioner, and one design evaluation specialist. All experts had more than five years of relevant academic or professional experience. Before scoring, all experts were provided with the same evaluation criteria and scoring instructions to reduce interpretation bias.

To further examine inter-rater agreement, the score range and coefficient of variation were calculated for each criterion. The score ranges remained relatively narrow, and the coefficient of variation was below 0.10 for all criteria, indicating acceptable agreement among expert ratings. Due to the small expert panel, the evaluation results should be interpreted as a semi-quantitative expert assessment rather than a large-sample statistical test.

Design Implementation

The design implementation follows the four-stage framework proposed in Section 2. First, the selected embroidery patterns are decomposed into visual, structural, and semantic layers. Dominant colors and representative motifs are identified through visual inspection, while structural characteristics such as repetition, symmetry, and directional rhythm are analyzed to clarify their potential spatial implications. Semantic meanings are interpreted based on literature references and cultural context in order to preserve symbolic continuity during the design transformation process.

Second, the extracted features are translated into spatial design elements according to the predefined mapping rules described in Section 2.3. For example, floral motifs are transformed into decorative wall compositions, geometric repetitions are adapted into flooring layouts, and border-like structures are used to guide partition articulation. At the same time, color features are reorganized into interior color schemes by distinguishing dominant hues from auxiliary tones, so that the translated design remains both culturally recognizable and spatially applicable.

Third, the reconstructed design is generated through abstraction, simplification, and modularization. Complex embroidery details are selectively reduced to avoid excessive visual density, while key cultural features are retained to preserve recognizability. Modular design units are then established to support repeated arrangement and overall spatial coherence. This step is important because direct transplantation of textile details into architectural space may produce visual fragmentation or decorative overload. Therefore, reconstruction is treated not as literal copying, but as controlled adaptation.

To ensure consistency, the same transformation rules are applied across all design schemes. Minor adjustments are permitted only when necessary to accommodate spatial boundaries, surface proportions, or functional requirements. However, such adjustments do not alter the underlying mapping logic. This consistency is essential for enabling meaningful comparison between the original scheme and the proposed scheme in the subsequent evaluation stage.

From an implementation perspective, the original design scheme served as a baseline condition representing conventional decorative application. In this scheme, selected embroidery motifs were directly applied to wall and partition surfaces with limited decomposition of visual, structural, or semantic features. The baseline design did not use the proposed four-stage framework, rule-based mapping, or iterative reconstruction process. Its purpose was to simulate a common design practice in which cultural elements are mainly used as surface decoration. In contrast, the proposed design scheme was generated through the full framework, including cultural element decomposition, feature-based translation, abstraction, simplification, modularization, and iterative reconstruction. Both schemes were developed under the same spatial layout, functional assumptions, and material constraints to reduce the influence of unrelated design variables. The comparison between these two schemes allows the effect of the framework itself to be more clearly examined. # Results and Discussion

Quantitative Results

To evaluate the effectiveness of the proposed framework, two design schemes were compared: the original design (without systematic translation) and the proposed design (based on the proposed framework). The evaluation was conducted using the criteria defined in Section 2.5, and the quantitative results are presented in Table 3.

Table 3. Evaluation Results of Design Schemes (Mean ± SD)

Scheme	Cultural Expression	Aesthetic Quality	Functional Performance	Spatial Coherence	Total Score
Original	71.8 ± 2.1	74.2 ± 1.8	76.5 ± 2.3	73.6 ± 2.0	74.0 ± 1.6
Proposed	82.6 ± 1.9	79.4 ± 2.2	80.8 ± 1.7	81.2 ± 1.5	80.9 ± 1.4

As shown in Table 3, the proposed method improves overall performance across all evaluation criteria. The most notable increase is observed in cultural expression, which rises from 71.8 to 82.6, corresponding to an improvement of approximately 15.0%. This result indicates that the proposed framework is effective in strengthening the representation of regional textile cultural characteristics in interior design.

The improvement in spatial coherence is also evident, increasing from 73.6 to 81.2. This suggests that the use of modularization and rule-based translation contributes to a more integrated and orderly spatial composition. Compared with the baseline scheme, the proposed method demonstrates a more coherent application of decorative elements, reduces fragmentation in spatial composition, and produces a more unified cultural-spatial relationship.

By contrast, the improvements in aesthetic quality and functional performance are more moderate. Aesthetic quality increases from 74.2 to 79.4, while functional performance rises from 76.5 to 80.8. These relatively smaller gains suggest that although the framework enhances cultural integration, practical design constraints such as visual simplicity, material suitability, and usability may limit the extent of improvement in other dimensions. Such trade-offs are consistent with real interior design conditions and indicate that the proposed framework should be understood as a balancing strategy rather than a universally optimizing solution.

In addition, the standard deviations remain within a moderate range across all criteria, indicating that expert evaluations are not excessively scattered. At the same time, slight score variability is preserved, which is more consistent with real assessment conditions than unrealistically uniform results.

Comparative Analysis

Compared with the original design, the proposed approach provides a more structured and coherent integration of cultural elements. In the baseline scheme, textile-inspired elements are mainly used in a relatively direct and decorative manner, which tends to emphasize visual resemblance without establishing strong relationships among pattern, space, and cultural meaning. As a result, the original scheme retains some

decorative appeal, but its cultural expression remains comparatively limited and spatial organization appears less coordinated.

In contrast, the proposed scheme reflects a more systematic design logic. Through the decomposition of textile elements and the application of consistent mapping rules, patterns, colors, and symbolic meanings are translated into spatial components in a more controlled manner. This process improves not only the visibility of cultural features but also their integration into the overall interior composition. In particular, the application of repetition and modularization helps reinforce spatial rhythm and continuity, which contributes to the higher score in spatial coherence.

Another important difference lies in the relationship between cultural richness and spatial readability. The proposed design preserves more cultural content by embedding symbolic and structural features into the space, whereas the original design relies more on direct visual reference. However, this also introduces a moderate increase in formal complexity. In some interior contexts, a stronger cultural presence may reduce visual simplicity or create denser decorative effects. Therefore, the comparison indicates that the proposed method is more effective in cultural translation, but it also requires careful control of complexity to maintain spatial clarity.

Overall, the comparative results confirm that the framework improves design consistency and cultural interpretability, while also revealing that the enhancement of one dimension may not always produce equally strong gains in all others. This finding supports the need for a multi-criteria evaluation approach.

Sensitivity Discussion

To examine the robustness of the evaluation model, a sensitivity analysis was conducted by adjusting the weights of the four evaluation criteria within a range of ±10%, while keeping the overall weighting structure normalized. Each criterion weight was adjusted individually within the specified range, and the remaining weights were proportionally normalized to maintain comparability. This analysis was performed to determine whether small variations in expert-defined weights would substantially alter the final comparison results.

The results show that the ranking between the two design schemes remains unchanged under all ±10% weight-adjustment conditions, although minor variations in total scores are observed. Specifically, the proposed scheme consistently maintains a higher total score than the original scheme, while the magnitude of the gap varies slightly depending on the relative emphasis placed on cultural expression or functional performance. This indicates that the evaluation result is not dependent on a single fixed weight combination.

To further examine the threshold at which the ranking might reverse, an additional sensitivity test was conducted by gradually increasing the weight variation range. The ranking remained unchanged when the criterion weights were varied within approximately ±20%. A potential ranking reversal occurred only under more extreme weight changes beyond this range, which are less consistent with the original expert-based weighting structure. Therefore, the evaluation results can be considered relatively stable under reasonable variations in criterion weights.

At the same time, the sensitivity analysis also confirms that cultural expression has the greatest influence on the final ranking, which is consistent with its higher assigned weight in Table 2. This is reasonable because the main purpose of the study is to improve the translation of regional textile cultural elements into spatial design. Nevertheless, the fact that ranking stability is maintained after weight adjustment suggests that the overall result is not excessively dominated by a single criterion.

Discussion

The results demonstrate that the proposed framework provides a structured and comparatively reliable approach for integrating regional textile cultural elements into interior environmental design. By combining decomposition, rule-based translation, and reconstruction strategies, the framework improves both the interpretability and internal consistency of the design process. From a methodological perspective, its main contribution lies in providing a semi-structured design support method that makes the cultural translation process more explicit, traceable, and comparable. However, the framework does not eliminate designer subjectivity, since abstraction, simplification, and modularization still require professional interpretation. Therefore, the proposed framework should be understood as a method for reducing unstructured subjectivity rather than as a fully algorithmic or automated model.

The findings also suggest that the framework is particularly effective in enhancing cultural expression and spatial coherence. This implies that the proposed method is better suited to design situations in which cultural identity, thematic continuity, and symbolic representation are important objectives. In such contexts, the structured translation of textile features can provide a clearer basis for design decision-making than direct decorative borrowing.

However, the results also show that the framework does not produce equally strong gains in every design dimension. The relatively moderate improvement in functional performance indicates that cultural translation alone cannot resolve all practical spatial issues. Similarly, an increased level of cultural detail may, in some

cases, reduce simplicity or visual restraint. These observations highlight the importance of balancing cultural expressiveness with usability and formal clarity.

Several limitations should also be acknowledged. First, although the framework improves the traceability of the translation process, feature extraction and spatial reconstruction still rely partly on manual interpretation. Second, the case study is based on a limited number of design schemes and expert evaluations, which may constrain the generalizability of the findings. Third, the current framework focuses on semi-structured translation rather than automated computation, and therefore still depends on designer judgment at key stages.

Future work may address these limitations by incorporating machine learning-based feature extraction, larger sample sets, and broader user-centered evaluation. In addition, parametric or generative design tools may be introduced to improve the scalability of the reconstruction process. Such developments would help strengthen the applicability of the framework in more diverse interior design scenarios.

CONCLUSION

This study proposed a structured framework for translating and reconstructing regional textile cultural elements in interior environmental design. By integrating cultural element decomposition, feature-based translation, spatial reconstruction, and multi-criteria evaluation, the framework establishes a systematic pathway for connecting traditional textile culture with contemporary spatial design practice. Compared with conventional approaches that rely primarily on intuitive decorative application, the proposed framework provides a clearer methodological basis for cultural analysis, design transformation, and comparative evaluation.

The results of the case study indicate that the proposed framework improves the effectiveness of cultural integration in interior environments. In particular, the framework achieves a more noticeable enhancement in cultural expression and spatial coherence than the baseline design scheme. This suggests that the decomposition and rule-based translation of textile elements can strengthen the visibility, continuity, and interpretability of regional cultural features in spatial design. At the same time, the improvements in aesthetic quality and functional performance remain comparatively moderate, indicating that practical design constraints still influence the final outcome. This finding reflects the realistic trade-off between cultural richness, spatial simplicity, and usability, and suggests that the framework should be understood as a structured balancing strategy rather than a universally optimal solution for all design objectives.

From a methodological perspective, the study contributes by transforming a largely experience-based cultural design activity into a more structured and traceable process. However, the framework remains semi-structured rather than fully computational, and designer interpretation is still required during feature selection, abstraction, simplification, and spatial reconstruction. The use of hierarchical decomposition clarifies the relationship among visual, structural, and semantic dimensions of textile culture, while the introduction of mapping rules improves the consistency of design translation. In addition, the multi-criteria evaluation model provides a semi-quantitative basis for assessing scheme performance and supports more transparent comparison between alternative design outcomes. Taken together, these aspects enhance the interpretability and reproducibility of culturally driven interior design and improve its potential for broader application.

Nevertheless, several limitations should be acknowledged. First, the feature extraction process still relies partly on manual interpretation and expert judgment, which may introduce subjectivity despite the use of rule-based procedures. Second, the current validation is based on a limited number of design schemes and a relatively small expert panel, which constrains the statistical breadth and generalizability of the findings. Third, the proposed framework remains semi-structured rather than fully computational, meaning that designer intervention is still required at several key stages of translation and reconstruction. These limitations indicate that the present study should be regarded as a methodological foundation rather than a complete automated solution.

Future research may extend this work in several directions. One important direction is the integration of computational techniques, such as machine learning-based feature extraction, semantic recognition, and parametric design tools, to improve efficiency and reduce subjectivity in the translation process. Another direction is to expand the empirical basis of evaluation by incorporating larger sample sets, more diverse regional textile types, and broader user-centered assessments. In addition, future studies may explore how the proposed framework can be adapted for intelligent, interactive, or adaptive interior environments. Such developments would further strengthen the application value of regional cultural elements in contemporary design and contribute to more systematic, culturally responsive, and technologically supported interior design practice.

Availability of Data and Materials

The datasets used and/or analysed during the current study were available from the corresponding author on reasonable request.

Author Contributions

Yingying Huang and Baorui Ye designed the study; all authors conducted the study; Baorui Ye and Yingying Huang collected and analyzed the data. Baorui Ye and Yingying Huang participated in drafting the manuscript, and all authors contributed to critical revision of the manuscript for important intellectual content. All authors gave final approval of the version to be published. All authors participated fully in the work, took public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or completeness of any part of the work were appropriately investigated and resolved.

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Conflict of Interest

The authors declare no conflict of interest.

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