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Modern Home Design Inspired by Jingchu Culture Through Intelligent Sensing and the Internet of Things: A Spatial Aesthetics Perspective

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Abstract
Contemporary residential design does not always account systematically for the different requirements, practical constraints, and aesthetic preferences of the people who use domestic spaces. When information about occupants and their activities is incomplete, design decisions may not respond adequately to changing household needs, and proposed spatial arrangements can be difficult to revise. This study examines modern home design from the perspective of spatial aesthetics and explores how intelligent sensing and Internet of Things (IoT) technologies can support a more responsive design and management process. Particular attention is given to the relationship between modern residential environments and the visual, spatial, and cultural characteristics associated with Jingchu heritage. The research discusses the integration of traditional and contemporary design approaches, the interpretation of regional decorative and spatial elements, and the use of computational methods in design evaluation and management. By considering intelligent sensors, networked systems, clustering analysis, and cultural interpretation together, the study offers an interdisciplinary discussion of ways to connect contemporary domestic functions with regional identity. The analysis emphasizes the continuing value of traditional cultural knowledge for designing living environments that are technologically adaptable, aesthetically meaningful, and responsive to occupants' needs.

Index Terms Spatial aesthetics; Jingchu culture; Modern home design; Internet of Things; Intelligent sensing; Clustering optimization

I. Introduction

As living standards have improved, residents have increasingly emphasized the aesthetic quality of their homes alongside comfort, functionality, and practical convenience. Domestic environments support everyday activities while also shaping psychological experiences, perceptions of place, and emotional responses to the surrounding space [1]. When occupants interact with a residential environment, differences in its proportions, materials, lighting, and organization can create distinct atmospheres and aesthetic impressions. Spatial aesthetics therefore encompasses both physiological perception and psychological interpretation; it concerns how visual characteristics are experienced and how people assign meaning and value to their living surroundings. Understanding these relationships is important when planning domestic environments that respond to residents' practical requirements and their expectations of cultural and aesthetic quality.

Aesthetic preferences differ across historical periods, geographical regions, social groups, and cultural traditions. Personal experience, educational background, cultural knowledge, and everyday patterns of life all contribute to these differences [2]. Against this background, intelligent sensing and Internet of Things (IoT) technologies offer opportunities to examine how modern residential design can respond more effectively to changing needs. Networked devices can support environmental monitoring, information collection, and the management of selected home functions, thereby providing an additional technical dimension to architectural and interior design [3]. Nevertheless, the combination of domestic spatial planning, intelligent sensing, and cultural expression remains insufficiently developed in many design applications. Studying these elements within a single discussion can broaden the scope of contemporary home-design research and provide a foundation for considering both spatial experience and technological adaptability.

The cultural significance of residential architecture cannot be understood without reference to the traditions from which its spatial arrangements, ornamental practices, and construction methods have developed. Rapid modernization and urbanization have changed building practices and increased the use of standardized design solutions, sometimes weakening the continuity of traditional craft knowledge and regional

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architectural expression [4]. Integrating contemporary design with locally rooted cultural traditions is therefore relevant not only to the historical understanding of Chinese homes but also to the preservation, adaptation, and continued development of architectural heritage [5]. Residential spaces provide evidence of changing economic conditions, social relations, ethical values, philosophical ideas, and technological capabilities. Chinese domestic architecture can consequently be read as a material record of historical and cultural development. In the Jingchu region, regional customs and architectural practices form part of this broader heritage, contributing distinctive resources for contemporary spatial design and cultural interpretation [6]. Their considered integration can help designers preserve meaningful connections with local history while responding to present-day household functions.

As cities develop, their architecture records successive stages of social change and reflects the cultural character of particular places. Regional design traditions contribute to these identities and offer resources for contemporary architectural expression [7]. At the same time, globalization and the circulation of international design styles have increased the variety of residential forms available to designers and occupants. The resulting interaction between Jingchu traditions and modern international approaches should not be treated as a simple opposition between old and new. Instead, it raises questions about which cultural features can be adapted, how they can be interpreted in present-day spaces, and how digital documentation might support their continued use [8]. Addressing these questions calls for a clear account of local design characteristics and a careful understanding of their relationship to contemporary expectations.

Contemporary Chinese residential design encompasses a wide range of international and regional influences, including high-rise housing, modernist interiors, and European-inspired decorative approaches. Such diversity can be valuable because it expands design possibilities and encourages experimentation with spatial form and construction. However, the adoption of visually striking forms does not automatically ensure that a building reflects the cultural history of its location. Some residential projects prioritize novelty and external appearance while paying comparatively little attention to traditional regional spatial concepts or the cultural meanings associated with particular details [9]. An approach informed by Jingchu culture should therefore seek more than the superficial application of familiar motifs; it should examine how spatial hierarchy, materials, ornament, and the experience of the home contribute to an integrated regional expression.

Accordingly, this study examines the artistic and spatial characteristics of traditional Chinese residential design to identify principles that may inform contemporary homes. It considers the formation of domestic architectural traditions, cultural elements associated with Jingchu, the composition of residential space, and the interpretation of decorative and construction techniques. Intelligent sensing and IoT technologies are considered as supplementary tools for monitoring and managing modern living environments, while computational design methods are discussed as possible supports for organizing and comparing design information. The broader aim is to encourage a distinctive approach to contemporary residential design in which functional requirements, spatial aesthetics, regional identity, and appropriate technology are considered together rather than as unrelated design concerns.

II. Optimization of Clustering Algorithms

This section outlines computational ideas relevant to organizing design information, including clustering analysis, normalization, and similarity assessment. Clustering methods group observations according to selected features, but their practical usefulness depends on the available data, the choice of similarity measure, and the criteria used to evaluate the resulting groups. The mathematical discussion also incorporates geometric crease equations expressed through points and perpendicular directions. Their relationship to the proposed clustering procedure remains to be established through an explicit computational formulation. The two geometric expressions are presented in Eqs. (1) and (2):

$$F_1(s) = p_1 + \frac{1}{2}(d_1 - p_1) + s(d_1 - p_1)^{\perp}, \tag{1}$$

$$F_2(s) = p_1 + \frac{1}{2}(d_2 - p_1) + s(d_2 - p_1)^{\perp}. \tag{2}$$

The midpoint of the relevant geometric segment can then be combined with a direction vector perpendicular to that segment. This provides the parametric representation of a possible geometric locus. The more general expression is given in Eq. (3), where the position varies with the scalar parameter w. In a computational design setting, such expressions can describe geometric relations, but additional explanation is required before they can be interpreted as steps in a clustering optimization algorithm.

$$Z_{EI}(w) = P_{EI}^{\mathrm{mid}} + w \cdot v_{EI}^{\mathrm{perp}}. \tag{3}$$

Before comparing numerical design attributes, the selected measurements may require normalization so that differences in scale do not dominate the similarity calculation. Eq. (4) is intended to represent a minimum–maximum transformation of the observations $x_1, x_2, \ldots, x_n$. The displayed expression requires mathematical verification; the placement of the minimization and maximization indices should be checked against the intended implementation before this equation is used for reproducible analysis.

$$y_i = \frac{x_i - \dfrac{\min\{x_j\}}{1 \le j \le n}}{\dfrac{\max\{x_j\}}{1 \le j \le n} - \dfrac{\min\{x_j\}}{1 \le j \le n}}. \tag{4}$$

The geometric construction also considers a point L on the straight line through G and H, subject to a specified distance d from point I. Eq. (5) presents the corresponding parametric line as stated in the original formulation. Its direction vector

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should be verified against the coordinates of the two endpoints, especially if the expression is intended to support a geometric construction or subsequent numerical calculation.

$$F_{GH}(w) = G + w(G + H). \tag{5}$$

A related crease construction is described by considering points E and L. Their midpoint and a perpendicular direction vector are used to express the corresponding line in parametric form, as shown in Eq. (6). The geometric expressions illustrate the role of coordinate-based descriptions in design computation, although a direct optimization objective has not been established linking these constructions to the clustering results.

$$Z_{EL}(w) = P_{EL}^{\text{mid}} + w \cdot v_{EL}^{\text{perp}}. \tag{6}$$

A second scaling procedure standardizes the observations by subtracting their arithmetic mean and dividing by the sample standard deviation, as shown in Eq. (7). This transformation is intended to center the observations at zero and express dispersion in standardized units. The arithmetic mean and sample standard deviation employed in the transformation are defined in Eq. (8). Because the denominator uses $n-1$, the distinction between sample and population variance should be maintained when reporting the statistical properties of the transformed data.

$$y_i = \frac{x_i - \overline{x}}{s}, \tag{7}$$

The corresponding statistical quantities are defined by Eq. (8):

$$\overline{x} = \frac{1}{n}\sum_{i=1}^{n} x_i, \quad s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \overline{x})^2}. \tag{8}$$

Similarity between observations can be evaluated through their feature vectors. In particular, cosine similarity describes the orientation of two vectors and is frequently used when the direction of a multivariate representation is more important than its magnitude. The formulation is presented in Eq. (9). The denominator in that expression should be checked before computational use, because the conventional cosine measure employs the product of the Euclidean vector norms, not the product of the squared norms.

$$d(x_i, x_j) = \cos(\vec{x_i}, \vec{x_j}) = \frac{\sum_{k=1}^{M} x_{ik}x_{jk}}{\left(\sum_{k=1}^{M} x_{ik}^2\right)\left(\sum_{k=1}^{M} x_{jk}^2\right)}. \tag{9}$$

The clustering framework described in this study is discussed in terms of a population space and a belief space, an organization associated with knowledge-guided evolutionary search. The population space can represent candidate groupings of design observations, whereas the belief space can maintain information that guides subsequent search or selection. Figure 1 illustrates the conceptual structure used in the original manuscript. For application to residential spatial design, the framework would require an explicit account of the observations being clustered, the feature variables, the objective function, and the procedures used to assess clustering quality. Without those elements, its role should be understood as a proposed computational structure rather than a validated optimization method.

The design approach follows a macro–meso–micro sequence that links the overall spatial organization of a residence to the arrangement of intermediate interfaces and finally to individual decorative or structural elements. This hierarchy is compatible with examining traditional Chinese residential design at several spatial scales. The mesoscopic level mediates between larger spatial conditions and the arrangement of smaller components; decisions at each level influence the available design choices at other levels. Figure 2 summarizes this hierarchical logic. A coherent design process should therefore examine how regional cultural elements operate across scales, rather than treating isolated motifs as substitutes for an integrated spatial concept.

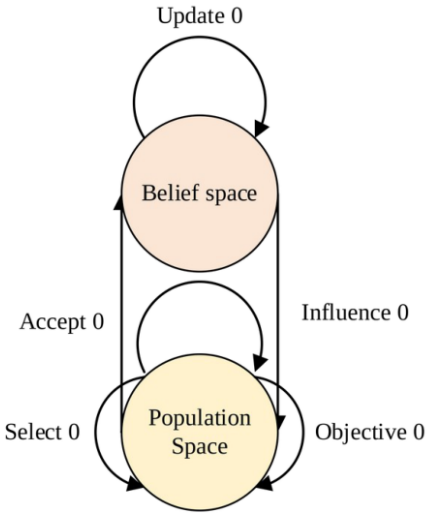


Figure 1: Conceptual Optimization Framework for Clustering Analysis

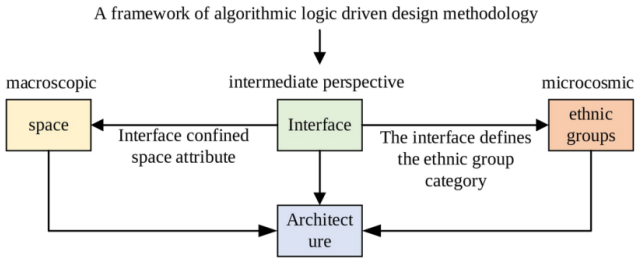


Figure 2: Hierarchical Framework for a Design Method Guided by Computational Logic

Observations assigned to the same cluster can be compared to examine their internal similarity, while observations in different clusters can be assessed to identify contrasting characteristics. The analytical framework also includes a city-comparison procedure, illustrated in Figure 3. Such a comparison could be relevant to the study of regional housing patterns if the urban observations, design attributes, and clustering

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criteria were specified. The underlying dataset and operational definition of this comparison remain unspecified, limiting its reproducibility.

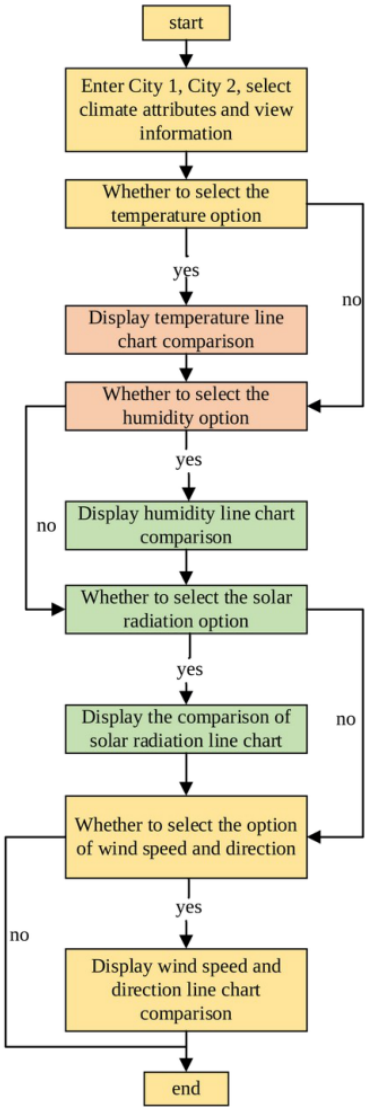


Figure 3: Workflow of the City Comparison Module

III. Methods

As modern residential design develops, the aesthetic experience of domestic space has become an increasingly important concern for both practitioners and occupants. Spatial quality cannot be assessed solely from the perspective of a designer's intended form; it also depends on how residents use a setting and respond psychologically to its proportions, visual relationships, furnishings, and environmental conditions. For this reason, the present discussion emphasizes a people-centered evaluation of residential aesthetics, including occupants' perceptions, preferences, and everyday spatial activities. Subjective assessment can provide information about the qualities that residents value, although its reliability depends on sampling, survey design, and consistent assessment conditions. The mathematical framework also includes expressions for structural cross-sectional areas in Eqs. (10)–(12). These formulations concern structural stress and buckling rather than a direct measurement of occupants' spatial requirements. Their role in the proposed residential evaluation should therefore be explained before they are used as evidence for design decisions.

$$A_i \begin{cases} \max(A_{\text{stress}}, A_{\text{buckling}}), & f_i < 0 \\ A_{\text{buckling}}, & f_i \geq 0, \end{cases} \tag{10}$$

$$A_{\text{stress}} = \frac{f_i}{\sigma_{\text{allowable}}}, \tag{11}$$

$$A_{\text{buckling}} = f\left(\frac{f_i (kL)^2}{\pi^2 E}\right). \tag{12}$$

An IoT-enabled home management system can be organized into functional layers that distinguish information acquisition, communication, processing, and application. Layered architectures are useful because they clarify the responsibilities of different components and support their integration within a wider residential management platform. Figure 4 presents the architecture considered in this study. To establish practical feasibility, future implementation should describe the devices, communication protocols, data processing requirements, and safeguards used to manage any personal or environmental information collected within the home.

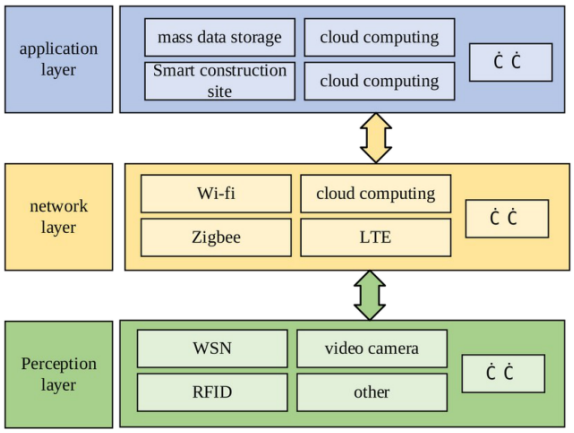


Figure 4: Layered Architecture of an IoT-Enabled Home System

The historical review indicates that traditional Chinese residential design continues to inform contemporary architectural thinking, even as building technologies and aesthetic preferences change. The search for a productive relationship between traditional spatial concepts and modern functional requirements has remained a central concern for designers who seek to preserve regional identity. Recent exchanges of design knowledge and technical expertise have also expanded the range of approaches available for adapting culturally significant forms to modern use. In parallel, clustering analysis offers a method for organizing formal observations: data are

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prepared, an appropriate clustering procedure is applied, and the resulting groups are interpreted in relation to the design question. Figure 5 illustrates these general stages. A successful application would need to connect the groups identified computationally to clearly defined spatial or cultural characteristics.

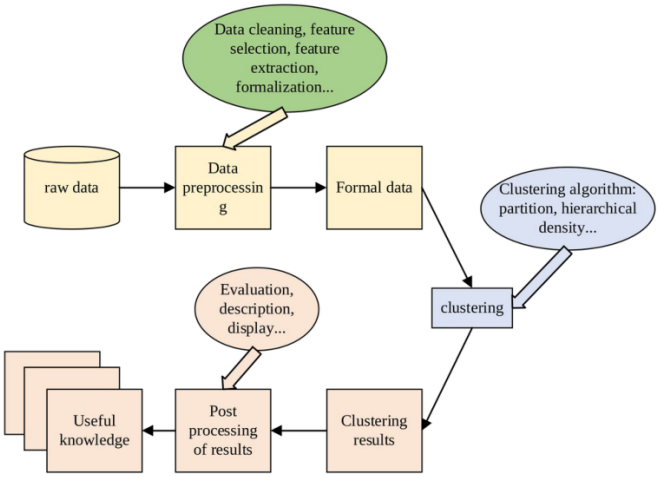


Figure 5: Steps in Clustering Analysis for Modern Residential Design

Important limitations nevertheless remain in how traditional architectural culture is interpreted within modern residential projects. Some designs emphasize recognizable external symbols without adequately considering the deeper spatial relationships, environmental responses, and construction traditions through which cultural meanings were historically expressed. The relationship between the residence and its natural setting is especially important, as are the sequence of spaces, the arrangement of built elements, and the material practices that give those spaces character. A finite-element workflow is also presented in Figure 6. Structural modeling can support the assessment of components where engineering performance is relevant; however, the study does not report a finite-element model or numerical results demonstrating how this workflow contributes to the aesthetic evaluation of Jingchu-inspired residential space.

The traditional frame system offers one starting point for examining how historical construction principles may be adapted to modern materials and residential requirements. A hierarchical design approach can connect roof and eave details, doors and windows, wall systems, and independent structural or ornamental components. Table 1 summarizes the source classification of these elements across external, internal, and transitional levels. The classification is useful as an organizational description, but the interpretation of each level should be linked to specific regional examples before claims are made about its unique relationship to Jingchu residential architecture.

Traditional domestic spaces embody cultural memory through their construction techniques, spatial hierarchies, materials, and everyday uses. Their preservation therefore in-

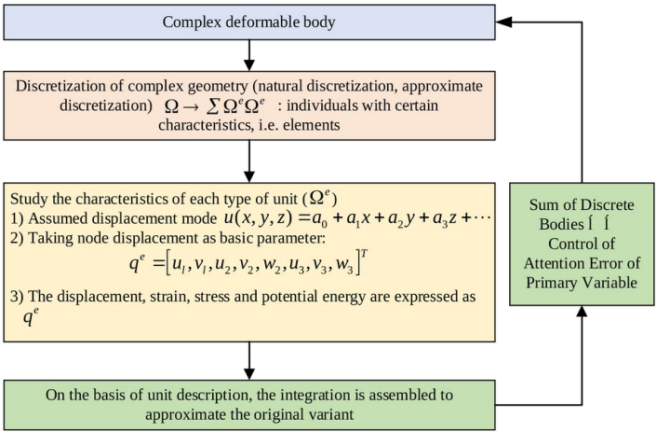


Figure 6: Finite-Element Analysis Workflow Discussed in the Design Framework

Table 1: Classification of Traditional Residential Design Elements by Hierarchical Level

External hierarchy	Roof decoration system	Warping, ridge, and tile systems, etc.
Internal hierarchy	Eave decoration system	Upper and lower eave components
Internal hierarchy	Door system	Doors, false doors, and hollow elements
Internal hierarchy	Window system	Windows and false windows
Internal hierarchy	Wall system	Shear walls, ordinary walls, and wall decoration
Transition level	Independent component system	Beauty-leaning rails, column-head components, railings, etc.

volves more than maintaining visible forms; it also requires attention to the knowledge and practices through which those forms were created and inhabited. Continued use and appropriate adaptation may provide opportunities for these traditions to remain meaningful within contemporary society. In this sense, the protection of traditional homes and the development of modern residential design are complementary concerns that can inform one another.

Conservation should protect historically significant residential environments while also supporting the continued practice of local building crafts and domestic customs. Designers can examine the aesthetic and functional principles embodied in traditional architecture and reinterpret them in response to changing households, building materials, and environmental expectations. Such reinterpretation requires a balance between cultural continuity and practical adaptation rather than the mechanical reproduction of historical appearances. A considered relationship between tradition and contemporary design can produce residential spaces that communicate a recognizable regional identity while remaining useful to present-day occupants.

IV. Case Study

Contemporary residential design continues to negotiate the relationship between historical reference and architectural innovation. Functionalist and structurally rational approaches emphasize the expression of actual spatial requirements and construction principles, while regional approaches seek to

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retain meaningful connections to local culture. These perspectives need not be mutually exclusive: a design may respond to modern needs while interpreting the spatial character and material traditions of its setting. Research on Chinese architectural regionalism also demonstrates that regional expression has taken different forms in response to changing cultural and professional conditions [10], [11]. Within this discussion, the systematic organization of design alternatives can support comparison and selection. Table 2 describes conceptual correspondences between biological evolution and genetic algorithms, providing terminology for considering search procedures in design exploration.

Table 2: Correspondence Between Biological Evolution and Genetic Algorithms

Biological evolution	Correspondence	Genetic algorithm
Individual species	→	Candidate solution to the problem
Individual competitiveness	→	Fitness function
Survival of the fittest	→	A solution with maximum fitness has the highest probability of being retained
Chromosome	→	Solution encoding
Gene	→	Encoded elements
Group	→	Selected group of solutions
Population	→	Group of solutions selected by fitness
Overlapping	→	Production of offspring from parents
Variation	→	Change to encoded components

As indicated in Table 2, an individual in an evolutionary system can correspond to a candidate design solution, while an individual's competitiveness is analogous to a fitness value used to assess the suitability of that solution. Concepts such as inheritance, variation, population, and selection provide a vocabulary for describing iterative searches through alternative configurations. Their relevance to residential design depends on how candidate solutions are encoded and how aesthetic, spatial, cultural, and functional objectives are translated into measurable evaluation criteria.

Building-envelope design also affects the energy performance of residential and other occupied buildings. Table 3 summarizes relationships among facade form, structural characteristics, glazing, ventilation, daylight, and potential energy-related consequences. These variables are relevant when a design incorporates traditional decorative patterns or spatial forms alongside contemporary performance requirements. The table is descriptive rather than an independent experimental assessment; quantitative energy conclusions would require climatic conditions, material properties, simulation settings, and comparable building configurations.

The parameterized design scheme includes the building's overall dimensions and orientation as well as variables describing subdivisions, surface bulging, glazing proportion, and hexagonal inlay patterns. Table 4 lists the proposed variables, numerical ranges, and specified step sizes or accuracies. These settings provide a basis for exploring alternative envelope geometries, but the range limits require justification against the intended building typology, dimensional units, and relevant performance constraints. In particular, a parameter search should distinguish geometric feasibility from an independently measured improvement in visual or environmental quality.

Tables 5 and 6 report descriptive measures for visual and physiological perceptions of spatial aesthetics under open and occluded conditions. Both tables show higher mean scores for the open condition than for the occluded condition: the visual-perception means are 3.412 and 2.148, respectively, while the physiological-perception means are 3.097 and 2.465. These descriptive differences are consistent with a more favorable evaluation of the open condition for the recorded measures, although the scale, sampling procedure, and interpretation of the dependent variable must be specified before broader aesthetic conclusions can be drawn. The reported visual-perception standard deviations require verification because their formatting differs markedly from the corresponding physiological measures.

Residential spaces are connected to the cultural traditions of the communities in which they are produced and inhabited. Traditional Chinese design has been influenced by philosophical concepts concerning the relationships among people, nature, and social order, including ideas commonly expressed through harmony and balance. These concepts contribute to the cultural significance of domestic spatial arrangements and may inform contemporary interpretations of residential identity. Figure 7 presents examples of traditional Chinese home-design elements, illustrating the kinds of formal and decorative resources that can be examined in a culturally informed design process. Their application should be based on documented provenance and regional context rather than presumed cultural universality.

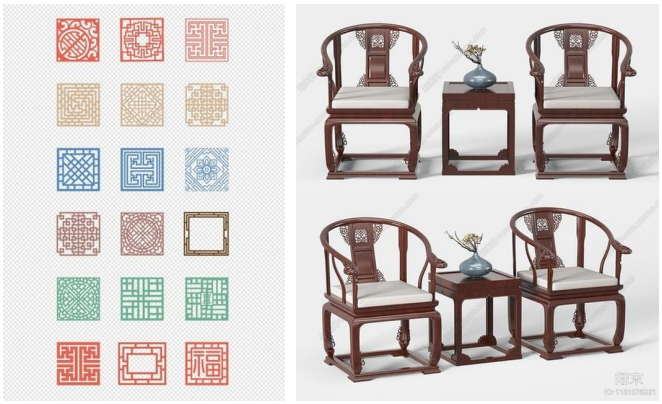


Figure 7: Elements of Traditional Chinese Residential Design

Aesthetic form is shaped by historical circumstances, local traditions, available materials, and the functions expected of a space. Domestic environments therefore communicate cultural values through more than their appearance alone: they also embody patterns of occupation, movement, privacy, and interaction. As contemporary design becomes more diverse, there are opportunities to incorporate regional elements within modern spatial and functional arrangements. Figure 8 shows a horse-head wall, a feature particularly associated with Huizhou architecture in Anhui rather than an exclusively Jingchu tradition. The example illustrates the importance of identifying the geographic and cultural origins of decorative

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Table 3: Building-Envelope Form, Materials, and Energy-Related Factors

Category	Relevant factor	Influence on form	Energy-related effect	Additional consideration
Conceptual design	Window-to-wall ratio	Large	Overall effect on energy conservation	—
Conceptual design	Shading components	Large	Overall effect on energy conservation	—
Conceptual design	Building-envelope structure	Small	Thermal insulation performance	Indoor air-conditioning energy
Physical indicators	Daylighting coefficient	Large	Insufficient daylight	Increased artificial lighting energy
Physical indicators	Ventilation performance	Small	Poor envelope ventilation	Increased mechanical ventilation energy
Physical indicators	Solar radiation heat gain	Large	Indoor temperature regulation	Air-conditioning energy
Material properties	Glazing characteristics	Small	Thermal insulation performance	Indoor air-conditioning energy
Material properties	Glazing characteristics	Small	Solar radiation effects	—
Material properties	Non-glazed materials	Small	Thermal insulation performance	Indoor air-conditioning energy
Other factors (unspecified)	—	—	—	—

Table 4: Parameters for a Modern Building-Envelope Design Scheme

No.	Design parameter	Symbol	Minimum	Maximum	Accuracy	Remarks
1	Building height	H	25.01	100.00	20.00	—
2	Bottom dimension	L	30.01	60.00	10.00	—
3	Building orientation	D	0.00	270.00	90.00	—
4	Building storey height	h	3.61	3.91	0.31	Fixed value
5	U-subdivision parameter	u	0.11	1.21	0.01	—
6	V-subdivision parameter	v	0.11	1.21	0.1	—
7	Cell bulge parameter	r	0.21	1.51	0.01	—
8	Glass ratio parameter	g	0.41	0.91	0.01	—
9	Hexagonal inlay parameter	t	0.1	1	0.01	—

Table 5: Visual Perception of Spatial Aesthetics by Condition

Visual condition	Mean	Reported standard deviation	95% CI lower limit	95% CI upper limit
1 – Open	3.412	439	3.371	3.454
2 – Occlusion	2.148	507	2.102	2.197

Table 6: Physiological Perception of Spatial Aesthetics by Condition

Physiological condition	Mean	Standard deviation	95% CI lower limit	95% CI upper limit
1 – Open	3.097	.313	3.068	3.127
2 – Occlusion	2.465	.413	2.426	2.503

elements before presenting them as representative of a specific regional design heritage.



Figure 8: Horse-Head Wall as a Regional Architectural Feature

The emotional significance of domestic space extends beyond its practical functions and relates to occupants' expectations of comfort, familiarity, cultural continuity, and personal expression. Design decisions about layout, landscape connections, materials, furnishings, light, and surface treatment can all contribute to how a home is perceived. A culturally informed approach should examine how these elements interact rather than treating ornament as the sole carrier of traditional meaning. Natural materials and the deliberate organization of interior and exterior relationships may also support aesthetic interpretations of harmony between human activity and the surrounding environment. However, links between particular philosophical traditions and specific material choices should be supported by appropriate historical evidence. For contemporary Jingchu-inspired design, the primary challenge is to distinguish documented local practices from wider Chinese architectural ideas and to interpret both carefully within the needs of present-day residents.

V. Conclusion

A systematic approach to contemporary home design should integrate regional cultural knowledge with modern functional requirements, building technologies, and occupants' aesthetic expectations. The present study has discussed spatial-aesthetic preferences, the reinterpretation of elements associated with traditional Chinese architecture, and the possible contributions of intelligent sensing, IoT systems, clustering analysis, and parameterized design. The descriptive perception results indicate differences between open and occluded spatial conditions, while the classification tables illustrate how design elements and technical variables can be organized for fur-

ther investigation. These observations suggest that meaningful regional expression requires an integrated consideration of spatial structure, cultural provenance, material selection, environmental response, and residents' experience. The study does not establish a causal improvement in home safety, energy efficiency, or aesthetic satisfaction attributable to the computational components because the corresponding implementation and evaluation protocols are not reported. Future research should document specific Jingchu case studies, collect participant-level aesthetic assessments, implement the proposed sensing platform, and compare design alternatives using reproducible performance and usability criteria. Such work could more clearly establish how traditional regional culture and contemporary intelligent technologies can contribute jointly to residential design.

Conflicts of Interest

The author declares that there are no known financial or non-financial conflicts of interest.

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Data Availability

The data are available from the corresponding author.

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