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Enhancing preservation of ancient buildings through color imagery analysis and activation: take yuelu academy as an example

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ABSTRACT

The pivotal role of color imagery analysis and activation has been insufficiently explored in the realm of historic heritage conservation. This study addresses this issue by introducing a comprehensive methodological framework that encompasses acquisition, analysis, activation, and application of color information based on the NCD (Nippon Color & Design) color system, an innovative color semantic quantification theory. Utilizing the venerable Yuelu Academy (from A.D. 976) as a case study, color imagery analysis methods across diverse spatial scales have been summarized. Subsequently, these results are applied to activate the surrounding environment color, as well as its cultural souvenirs. The methodologies outlined herein hold profound significance in addressing challenges concerning visual color continuity in the preservation of historic architectural landscapes, offering innovative perspectives.

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1. Introduction

Ancient buildings as tangible records of history, provide insights into a city's cultural evolution. However, many traditional ways of protecting and utilizing these architectures have become infeasible when facing ongoing social progress (Shan et al. 2022). To achieve the preservation and inheritance of cultural heritage amidst social change, it is essential to activate ancient buildings through authentic means (S. Wang et al. 2023).

Numerous studies and practices on the conservation and revitalization of ancient buildings have mainly focused on structure, elements, materials, etc., with less emphasis on color. Color, as an important element affecting visual perception, assumes a pivotal role in human interpretation of visual images (Elliot and Maier 2014). To strike a balance between heritage preservation and urban development, precision in extracting characteristic elements from ancient buildings becomes essential for modern revitalization in line with the authenticity principle.

Therefore it is imperative to incorporate color into the preservation and revitalization of ancient structures, as a systematic color record and subjective color imagery analysis enable the accurate identification of visitors' preferences for architectural color (de Medeiros Dantas et al. 2022; Hu et al. 2021). Additionally, they aid in achieving the optimal layout of facilities, landscapes, and products in the recreational zone of ancient buildings and in regulating color schemes in the surrounding area (G. Wang and Lu 2020).

Imagery, as a form of representation, refers to the imaginative portrayal stemming from memory or existing perceptual images (Xia and Chen 2009). In this sense, color imagery represents a blend of external objective colors and internal subjective emotions. The majority of previous studies in this field concentrate on the origins and influences of color imagery, which can be summarized into two main aspects: the formation of the object color prototype and the subjective imagery.

Regarding the formation of object color prototypes, French scholar Professor Jean-Philippe Lenclos (1999) discovered that color attributes fluctuate depending on the natural lighting conditions of distinct geographical settings, and he proposed the theory of color geography. Chen et al. (2014) pinpointed four influencing factors in architectural color culture: regional, cultural, religious, and ethnic. Huang (2019), by interpreting local cultural characteristics, pointed out that biological color prototypes are shaped by natural factors such as climate, weather, geographical conditions, and plant landscape, while cultural color prototypes are influenced by human factors including ethnic compositions, historical backgrounds, religious beliefs, folk customs, and humanistic spirits.

In terms of the formation of subjective imagery, Bekhtereva and Müller (2017) found that color can influence the duration of the attentional bias to briefly present affective scenes by facilitating the extraction of emotional content. Goldstein (1942) suggest that

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certain colors, such as red and yellow, elicit physiological responses that manifest as emotional experiences characterized by negative arousal, cognitive orientation focused on external stimuli, and behavioral expressions involving forceful actions. This hypothesis proposed a relationship between color perception and psychological as well as behavioral processes. Psychology also includes the concept of color association, defined as "the perception of color generated from non-visual sensory organs" encompassing "color of hearing, color of shape, color of gustation, color of smell and color of touch" (Safran and Sanda 2015).

When considering the method and theoretical framework for analyzing color imagery, it is worthwhile to examine the NCD (Nippon Color & Design) color system, which draws upon color psychology to provide a scientifically rigorous reference point (Huang and Chen 2019). The NCD color system was developed by the Nippon Color & Design Institute, established in 1966, and remains widely used nowadays. Based on the Munsell color system, the NCD color system further digitalizes and systemizes colors. The NCD color system features three primary characteristics:

(1) Constructing color impression coordinates based on color psychology, which establishes an intrinsic connection among color, psychology, and semantics, enabling us to "use color as use languages" (Kobayashi 2006a).
(2) Being strongly practical, and can establish relationships quickly within various fields such as fashion, architecture, home appliances, and automobiles.
(3) Using the SD (Semantic Differential) method, which is employed as a tool to compound different sensory organs' perceptions of similar imageries, to realize a synesthetic design with color as the entry point.

Combining the characteristics of the NCD method, it proves effective in analyzing the psychological imagery formed by the color of object entities in human visual perception. When applied to the conservation of ancient buildings, it becomes a valuable tool for analyzing their color imagery, thereby contributing to the protection and activation of colors. In the field of urban and architectural heritage conservation, the concept of "activation" has gained prominence, specifically denoting the "adaptive and effective reuse" of historic buildings (Penića, Svetlana, and Murgul 2015). For instance, the concept of "adaptive reuse" in European architectural heritage studies resonates with this idea, indicating selective reuse (Alhojaly, Alawad, and Ghabra 2022). Taiwan was the first to propose the concept of "heritage revitalization", emphasizing the balance between inheritance and innovation. Similarly, the Hong Kong government has progressively prioritized the conservation of historic buildings and their surrounding neighborhood and has launched the "Revitalizing Historic Buildings Through Partnership Scheme" to achieve a synergy between the preservation and development of these buildings (Cheung and Chan 2014).

By extension, the concept of color activation refers to conversing color prototypes as a prerequisite to invigorating their vibrancy and applying them in different contexts consciously. Based on existing theories and practices, color activation encompasses four methods: "simulative activation, nodal axis activation, symbolic activation, and color impression reconstructing" (Huang 2019). Differing from "museum-style conservation", the application of color activation in ancient buildings represents a preservation method that transforms static passive conservation into dynamic active utilization.

This study follows the NCD color analysis methodology to explore a systematic workflow involving "color information acquisition, color imagery analysis, and color activation application" of ancient buildings. For this purpose, we have chosen Yuelu Academy in Changsha, Hunan Province, China as an illustrative case. This approach is implemented across various spatial scales to adapt to the requisites of color design in diverse scenarios. The study's innovative aspects can be summarized as follows:

(1) Integration of color psychology and heritage conservation: The study pioneers the application of the NCD color system to the preservation of ancient buildings, recognizing the emotional and cognitive impact of color on human perception. This allows for infusing a human-centered perspective into the conventional approach of safeguarding ancient buildings solely based on architecture.
(2) Active Preservation through Color Activation: The paper advocates for an active preservation strategy that goes beyond passive conservation. It introduces the concept of color activation, which involves the conscious application of color prototypes to invigorate the vibrancy of ancient structures and their surroundings. This approach transforms static conservation into a dynamic process that engages with the environment and the community.

2. Methods

Incorporating the NCD color system, this study aims to construct a methodology for analyzing color imagery and color revitalization of ancient architecture (Figure 1).

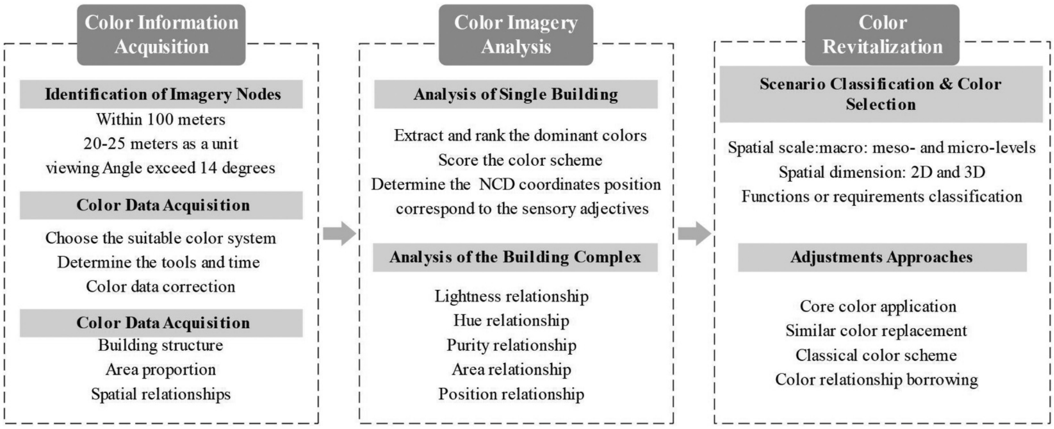


Figure 1. Methodological framework for analyzing and revitalizing color imagery.

2.1. Color information acquisition

2.1.1. Identification of imagery nodes

In external spaces, nodes are strategic focal points accessible to observers. The selection of nodes can directly influence how humans perceive the colors of historical buildings, commonly referred to as their color power. According to their functions, Lynch (2001) intended that nodes can be categorized into "connection nodes" in spatial structure and "gathering nodes" for human interaction. Gathering nodes play a pivotal role in forming the color power and color imagery of ancient buildings, and are frequently discernible through field research.

Furthermore, the suitable proportion of artificial color within the visual field of a node is essential for shaping color imagery. This factor is determined by the observing distance (Elliot 2015), which can be translated into the observing angle, horizontal line-of-sight distance, etc. Yoshinobu's (1975) application of the '20 to 25 meters as a unit module to orchestrate the rhythm of exterior spaces can alleviate the monotonous perception of extensive areas. Additionally, scholars have classified the horizontal view distances into several ranges: up to 100 meters constitute the section where the structure and image can be distinctly and accurately perceived; 100–1000 meters allows for observing the object's rough outline, and 1500 meters marks the boundary of vision (Dai and Xing 2012). Concerning the viewing angle, it is recommended to exceed 14 degrees for nodes characterized by a strong sense of enclosures, such as courtyard-style ancient buildings with a symmetrical layout. In this way, the sense of closure can be reduced, allowing for a broader field of vision to encompass the entire building (2001).

2.1.2. Color data acquisition

To effectively collect and analyze color data, the initial step involves defining the sample's scope and selecting a color system suitable for the research object (Liu, Liu, and Yuan 2016). Color image is the impression formed by the color of objective things in subjective perception. Based on color psychology, the NCD color system serves as a valuable tool for color imagery analysis.

When collecting color data, it is imperative to choose a fitting color extraction tool based on the attributes of the research object. Two main types of tools exist for this task: contact and non-contact. Contact tools, such as spectrophotometers, ensure high data accuracy by touching the research object. However, they are restricted to dry, flat, non-curved, and non-mirrored surfaces. Non-contact tools, such as digital cameras, can measure objects from a distance but are sensitive to environmental conditions. For optimal results and to mitigate disturbances from external elements, like light intensity, color temperature, and humidity, the ideal time for measurements is between 9 a.m. and 4 p.m. on cloudy days with high visibility or sunny days without direct sunlight (Apollonio, Gaiani, and Baldissini 2017). Additionally, when using a digital camera, utilizing the Axiomtek color card to correct color differences in photographs can be helpful.

Color correction is a requisite for the compiled data as well (Tu et al. 2019). To reinstate the object's true color under prevailing lighting conditions, importing the color photographs taken by the camera into the Axiomtek color card software is a possible method. Moreover, for objects with uneven color distribution, the photographs can be mosaic-assembled to obtain the average color value within a designated range of cells. It is crucial to emphasize that color correction stands as an indispensable step in data analysis, ensuring the accuracy and validity of the results.

2.1.3. Architectural chromatography collation

The color data collected from ancient buildings will be classified based on the building structure, area proportion, and spatial relationships (An et al. 2019). The RGB values of the colors will be quantified, documented meticulously, and compared with the 130 representative colors in the NCD color system to identify the most similar representative colors in aspects of lightness, purity, hue, and tone.

For buildings with discernible chronological differentiation or functional designs, the data should be collated according to different classifications, allowing for comprehending the changes in the color of ancient buildings over time and patterns of color in different functional designs. This will help make predictions for future developments in architectural color.

2.2. Color imagery analysis

2.2.1. Analysis of single building

The NCD color system employs multi-color schemes to correlate with psychological impressions. The analysis will encompass the establishment of four color assessment systems: hue & tone matching schemes, harmonization & highlighting schemes, color gradient & color separation schemes, and clear & dirty color schemes (Kobayashi 2006b), constituting four distinct groups of color reference expressions (Figure 2 and Table 1).

Concerning colors in three-dimensional space, the analysis should take into account the proportion and spatial position of different colors while depicting the architectural elevation color imagery. Extract the five colors that best represent the color imagery and center the most dominant color to form the architectural representative color scheme. Scores the scheme and determines a more accurate position of it on the NCD color scheme imagery coordinates. The corresponding sensory adjectives on the linguistic imagery coordinates potentially reflect the emotions elicited by the building.

2.2.2. Analysis of the building complex

People's perception of space extends beyond the compilation of individual color elements. Instead, it constitutes a comprehensive understanding stemming from a sequence of consecutive images and fragments (Loomis 2003). From the perspective of color theory, this refers to different color schemes and color relationships of architecture and the surrounding environment that are presented in successive images. J. Wang (2013) proposed that urban color encompasses "lightness relationship, hue relationship, purity relationship, area relationship, and position relationship". The initial three elements symbolize the interplay among the three pivotal elements of color, while the latter two pertain to the relationship between the "color gamut" that contains spatial information. Analyzing area relationships involves exploring the proportional distribution of color within sight, categorized into three types: dominant color covering large areas, auxiliary colors covering medium-sized areas, and embellishment colors covering small areas. Scheme relationships include the dominant-subordinate relationship, primary-secondary relationship, dichotomous or polychotomous relationship, and iconic embellishment relationships. Analyzing position relationships center on the arrangement and configuration of diverse colors within the space, encompassing inclusive, semi-inclusive relationships and adjacent relationships (Table 2).

In the evaluation of color imagery across different architectural scales, two color attributes on which the analysis is based can be summarized: absolute attributes and relative attributes. Absolute properties reflect the intrinsic attributes of individual colors, encompassing hue, brightness, and purity, and in

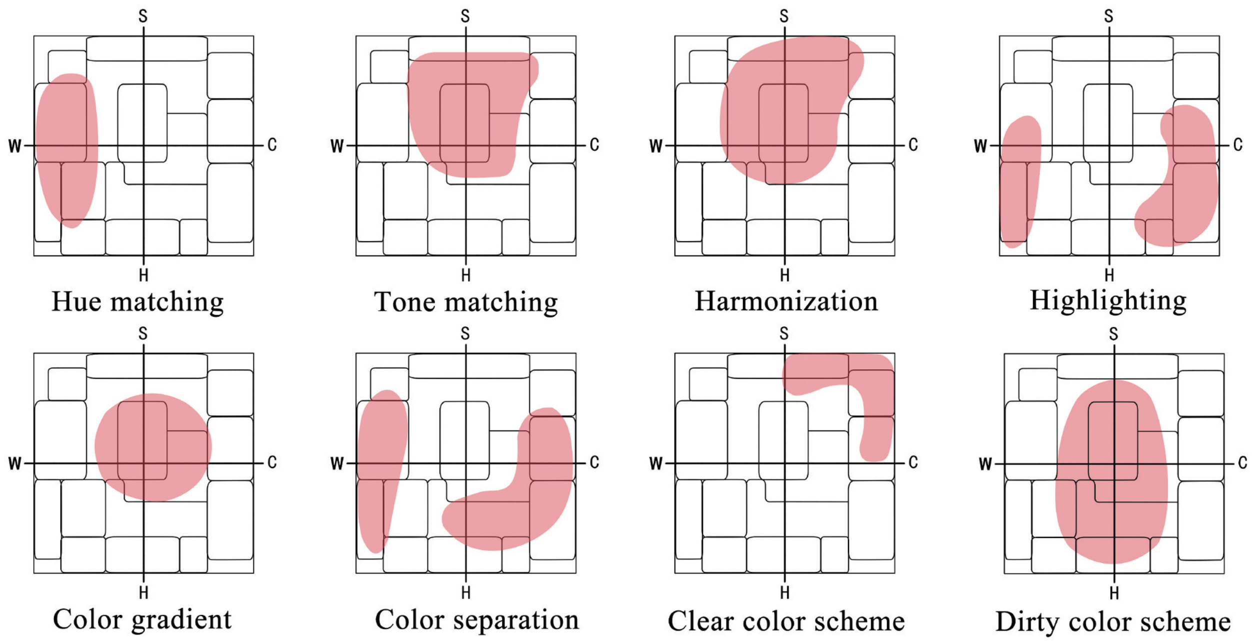


Figure 2. Schematic diagram of color matching techniques corresponding to the position of the color image coordinates.

Table 1. Summary of the color matching evaluation system.

Color Matching Tips	Color Logic	Color Imagery
Hue matching	4 to 5 hues; Warm tones dominated; Highly saturated colors are often used (V, S, B, Rp)	Exquisite Comfortable Sporty Luxurious
Tone matching	2 or 3 hues; Use uncolored color to adjust lightness; Tone gradient	Comfortable Elegant Sophisticated Poised
Harmonization	Same or similar hue or tone; grey is often used; Color gradients or separation by pastel colors	Comfortable Elegant Sophisticated Refreshing
Highlighting	Use of complementary and contrasting colors; White and black are often used; Separation of light and dark colors	Comfortable Refreshing Relaxing Sporty Modern
Color gradient	Hues are arranged in order of color circle; Hues in order of softness and hardness; Uncolored gradations in order of light and dark	Poised
Color separation	Warm & cool or contrasting hues are arranged at intervals; Light & dark or soft & hard tones are arranged at intervals; Black or white is often added to enhance the separation	Casual Relax Powerful
Clear color scheme	Cool color schemes; High brightness colors are often used (V, B, P, Vp); Shades matched with white or black	Suitable for expressing the glossiness of artificial materials
Dirty color scheme	Warm color palette; S (Strong), L (Light), Dl (dull), Lgr (Light Grayish), Gr (Grayish) matched with grey	Blending with natural material textures

architectural context, the area they occupy. It can be applied for analyzing single buildings and involves extracting representative color schemes based on the dominant color's proportion within the facade. Conversely, relative properties pertain to the relationships among colors, focusing on relative area and positional dynamics, which are pivotal in building complex analysis. This dual approach provides a comprehensive understanding of color interactions, essential for the conservation and revitalization of historic architectural environments.

2.3. Color activation

The analysis of color imagery mandates consideration of disparities across diverse architectural spatial scales and dimensions of color analysis. The activation and application of the outcomes can be tailored to the particular application scenarios and adjustment approaches.

2.3.1. Scenario classification and color selection

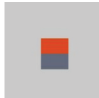
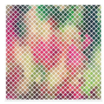
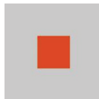
The color activation scenarios for ancient buildings can be classified into different types according to different standards, such as scale and dimension. In terms of scale, these scenarios can be divided into macro-, meso- and micro-levels. For instance, macro-level considerations color regulation within protected sections of historical architecture; meso-level assessments pertain to color referencing of individual historical buildings; and micro-level observations involve the formation of imagery within specific spatial nodes (Gou 2013). Concerning dimension, the scenarios can be classified into two-dimensional scenes and three-dimensional scenes. The former scenes mainly belong to the micro-level of the spatial scale, like the color design of creative souvenirs inspired by ancient architecture.

These classifications can be further specified based on their importance, hierarchical functions, and so on. Initially, color schemes should be chosen by the priority demand in the main color imagery database of ancient architecture. Once these primary requirements are fulfilled, supplementary refinements can be implemented to meet the emotional demands of the scenarios.

2.3.2. Adjustments approaches

Leveraging the considerations of absolute and relative color properties within the aforementioned methodology for color imagery analysis, this study proposes four applicable methods for color

Table 2. Summary diagram of color combination relationships.

Color gamut relationships		Specific content	Pictorial representation
Area Relationships	Dominant-subordinate	The area of the dominant color occupies most of the area, the rest of the color occupies small area, only as additional color; Strong contrast.	
	Primary-secondary	The area of dominant color, auxiliary color and embellishment color is gradually reduced; Medium contrast.	
	Dichotomous or polychotomous	The colors are equal in size or dispersed; Weak contrast	
	Iconic embellishment	Complex, disordered groups of colors; A color or a fixed combination of colors is constantly present in small areas, adding orderly clues to the disorder pattern; Weak contrast	
Location Relationships	Inclusive	All edges of colors are adjacent to each other; Strong contrast	
	Semi-inclusive	At least one side of the color is not adjacent to the other; Medium contrast	
	Adjacent	Only oneside of the color is adjacent; Weak contrast	

activation adjustment: Core color application, Similar color Substitution, Classical color scheme, and Color relationship borrowing. The former two methods emphasize color extraction or substitution based on the absolute properties of color, while the latter two focus on the application of color relationships and combinations. The specifics of each method are as follows:

(1) Core color application: Core colors are frequently appearing colors and those with important symbolic connotations. Ancient architectural imagery can be strongly represented and effectively amplified by the core colors.
(2) Similar color Substitution: Given that colors with similar tones or hues have analogous meanings, the core color could be replaced by a hue or tone from the color scheme that bears the closest resemblance. This substitution can effectively mitigate disparities in significance and guarantee the desired color imagery.
(3) Classical color scheme: By Analysing the frequency and proportion of individual colors in architecture, it becomes possible to uncover the principles governing architectural color arrangements that facilitate the establishment of associations with color imagery. Materials, technical limitations, and aesthetic traditions often lead to the use of specific color schemes among groups of buildings.
(4) Color relationship borrowing: Summarize the color scheme relationships identified within

the components of historical architecture, such as the light-dark, hue, and tone relationships. This consolidation provides a reference for relevant souvenirs.

3. Results for practical applications

Yuelu Academy, established during the Northern Song Dynasty, holds a distinguished status as one of the "Four major academies" in ancient China. Throughout different dynasties, spanning from the Northern Song Dynasty to the contemporary era, the architecture of Yuelu Academy has witnessed cultural and educational developments (Hongbo 2009). The architectural complexes in the Academy can be categorized into three main functional areas: teaching, rituals, and garden. The analysis will be conducted at both the individual and collective levels of architectures. Additionally, color activation methods will be particularly employed for its surrounding buildings and cultural souvenir products.

3.1. Color analysis of individual building

Guided by the principles of "axis-based analysis, functional zoning, and area reference", the research focuses on several key individual buildings as research objects. The research architectures have characteristics to accurately embody the essence of the academy: The Entrance gate, The Lecture Hall, The Imperial Library, Dacheng Hall, and Lushan Temple (Table 3).

3.1.1. The entrance gate

The entrance gate holds substantial importance as it greatly impacts visitors' initial perception of the academy. The findings show that the colors of the academy's entrance gate exhibit diminished saturation and brightness, accompanied by low purity, and minimal color variation, and tend to be "tone matching". The general color scheme pertains to the "dirty color scheme", with more tonal variation than hue variation. Additionally, there is an evident contrast between white and black. The tone from top to bottom shifts from dark to light and then back to dark again. The color imagery of the entrance gate's façade is bright and sophisticated (Figure 3).

3.1.2. The lecture hall

The Lecture Hall at Yuelu Academy is dominated by colorless and warm tones like red and orange, characterized by low lightness and saturation. Overall, the color scheme belongs to the "dirty color scheme", and the tonal variation is more obvious than the hue variation, which is typical of "tone matching". The Lecture Hall's colors are gradated in shades, incorporating black and white for heightened separation and distinct highlighting, showcasing classic color separation traits. Overall, the Lecture Hall's main faÃ§ade embodies a classical and archaic aesthetic in its color imagery (Figure 4).

3.1.3. The imperial library

The Imperial Library, a main structure of Yuelu Academy, is characterized by its use of uncolored and warm tones such as orange and yellow with low brightness and purity. The overall color scheme is "harmonization", with limited variation in hue. The tonal variation of the color palette is more evident, with the majority of the hues being dirty colors. The colors of the main faÃ§ade are arranged at intervals vertically, with the roof and glass spaced out. The tones are arranged at interval sections of light and dark tone. Nonetheless, distinct color separation or gradation is absent due to significant size differences among the color sections. In summary, the Imperial Library's main facade exudes classical and exquisite color imagery (Figure 5).

3.1.4. Dacheng Hall

Dacheng Hall is a prominent building at the ritual zone of Yuelu Academy. It primarily features warm and uncolored hues such as red, orange and yellow, exhibiting low purity and significant variations in brightness, which tends to be "highlighting". The main color scheme of the building doesn't seem to have a specific preference for hue and tone. As a result, it creates an overall impression of a "Dirty color scheme". The facade showcases a sequence of light-to-dark tones, devoid of distinct color separation or gradation. In conclusion, Dacheng Hall's main facade features a naturally vibrant and thick color imagery (Figure 6).

3.1.5. Lushan Temple

Lushan Temple exhibits a striking coloration composed primarily of hues of violet-red, yellow, blue-green, and uncolored shades of slightly lower brightness and purity, which create a distinct "dirty color scheme". The main color palette demonstrates significant variation, and shows strong contrast and dominance within the overall palette, which fits the characteristics of "hue matching" and "highlighting". In general, the main façade of Lushan Temple exudes a naturally vibrant and thick aesthetic in its color imagery (Figure 7).

Yuelu Academy comprises several ancient buildings, each serving a distinct function. The architectural color design is a vital element highlighting the unique aspects of each functional area. Teaching buildings and libraries predominantly feature low-purity colors like grey and white on their main facades, while the ritual area primarily displays high-brightness hues like

Table 3. Color analysis of individual buildings of Yuelu Academy.

The Architecture of Yuelu Academy		Hue Relationships	Brightness Contrast Relationships	Purity Contrast Relationships
Teaching zone	The Entrance Gate	/	Strong	Weak
	The Lecture Hall	Adjacent Hues	Moderate	Weak
	The Imperial Library	Adjacent Hues	Weak	Weak
Ritual zone	Dacheng Hall	Similar Hues	Strong	Weak
Garden zone	Lushan Temple	Contrasting Hues	Moderate	Weak

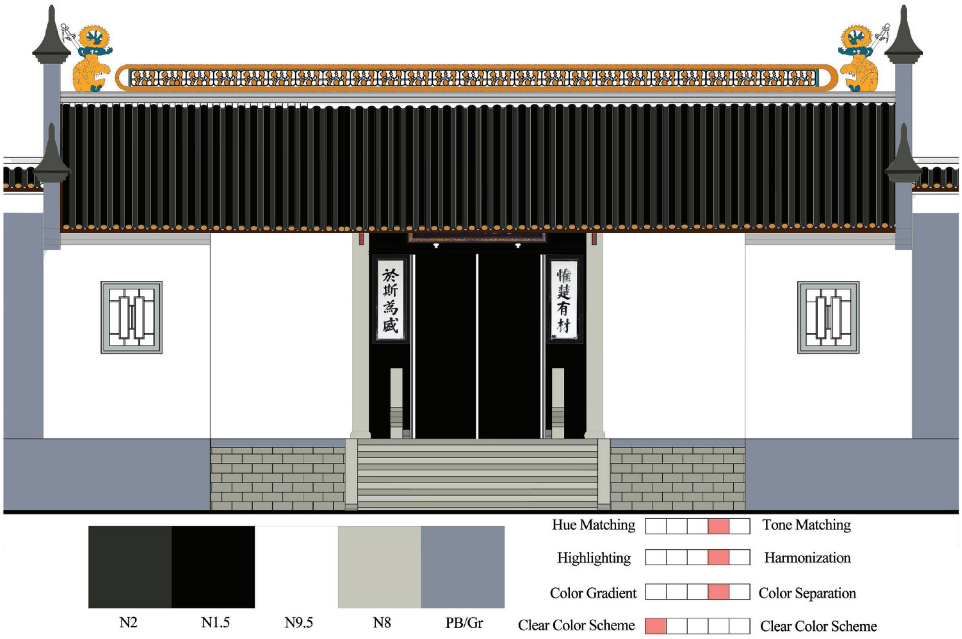


Figure 3. Color analysis diagram of the entrance gate.

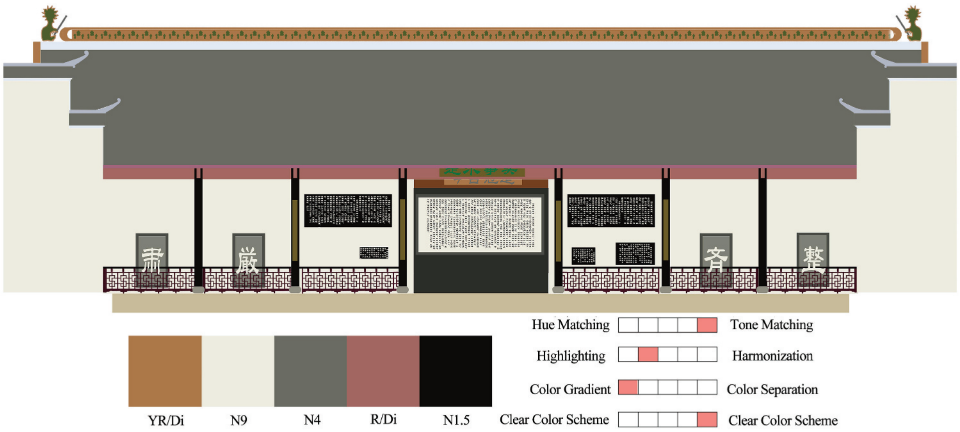


Figure 4. Color analysis of the lecture hall.

red and yellow. Additionally, the garden area boasts a relatively vibrant and lively color tone. The color design of academic architecture can be mainly attributed to the hierarchical system, Yin and Yang concepts, the Five Elements theory, and regional characteristics in ancient China. For instance, yellow symbolized sacredness and the highest status in ancient Chinese culture, solely adorning Imperial and significant temple buildings. Therefore, only the roofs of the academy's ritual areas bear this color. Similarly, following the Theory of the Five Elements, "water" is connected to the color black. the Imperial Library, serving as a repository for the collection of books should represent "water restraining fire". Consequently, the roof of the Imperial Library is grey-black (Gou and Wang 2010).

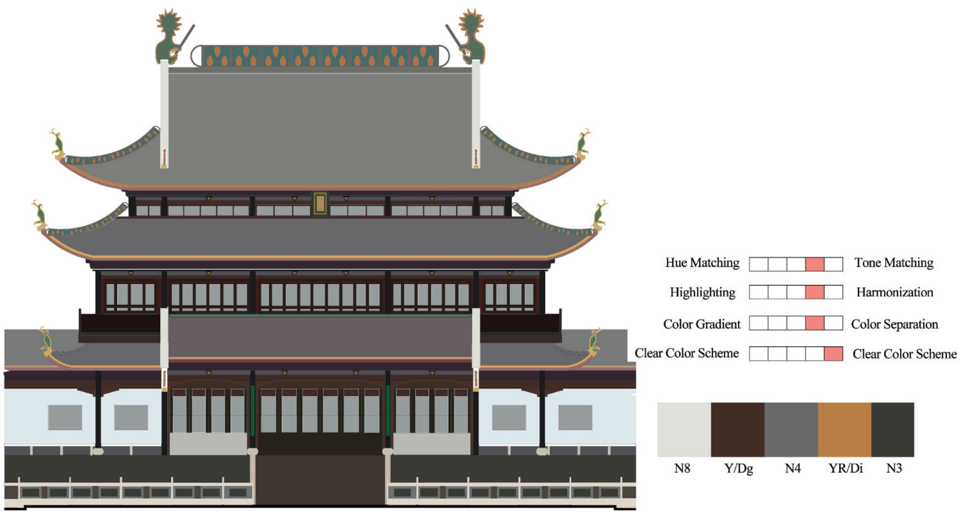


Figure 5. Color analysis of the imperial library.

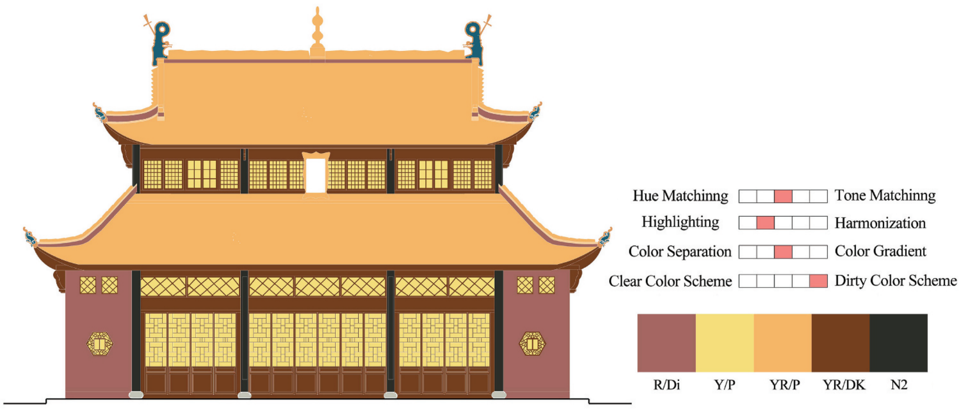


Figure 6. Color analysis of Dacheng Hall.

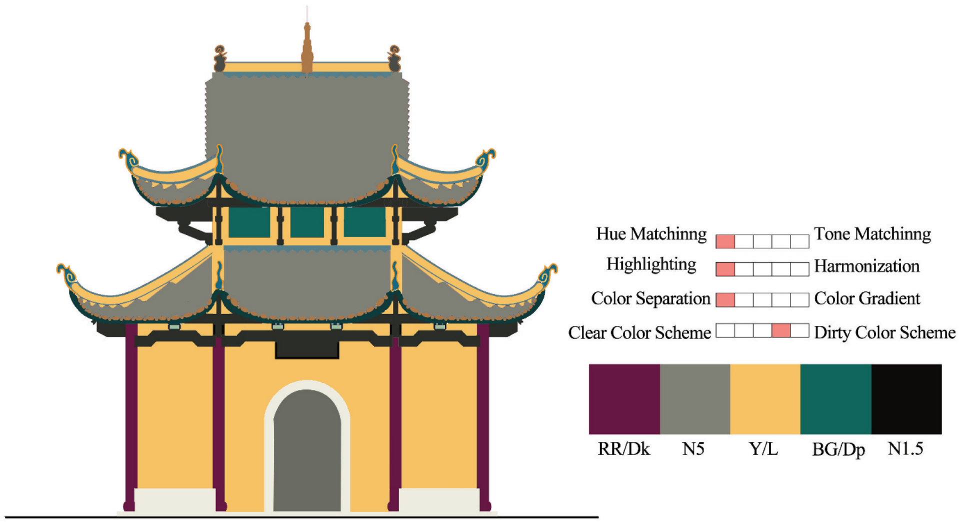
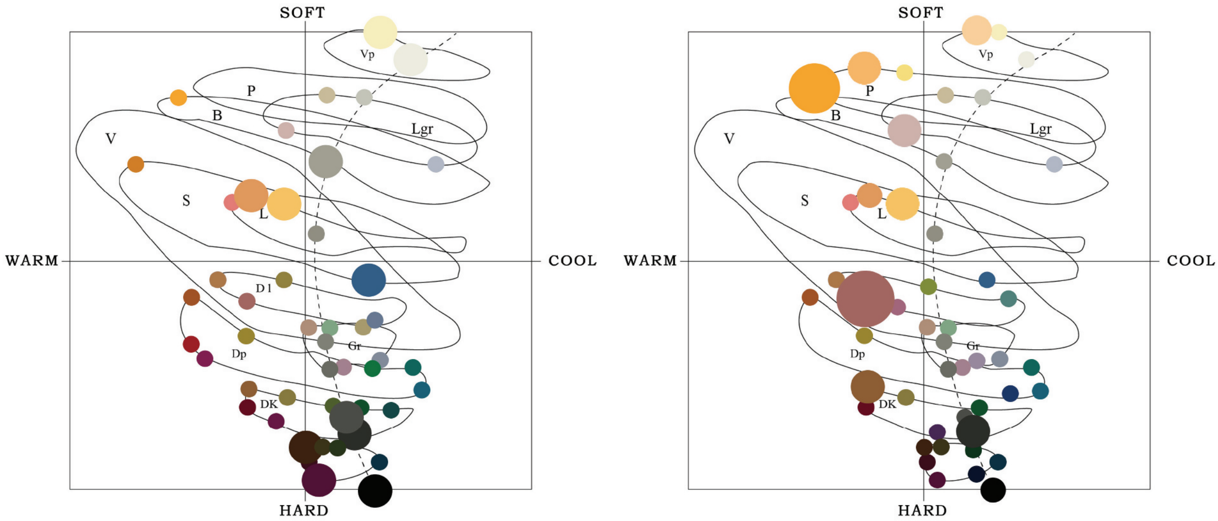


Figure 7. Color analysis of Lushan Temple.



(a) The axis of the Lecture Hall. (b) The axis of Confucius Temple.

Figure 8. Color analysis of the axes of yuelu academy.

3.2. Color analysis of building complex

The architectural design of Yuelu Academy building complex follows the traditional Chinese principles of "axial symmetry" and "scenery changing with pace", forming a sequential axial landscape (Tang and Chen 2014). Analysis reveals that the Confucius temple axis features more vibrant and vivid color types. Contrastly, the architectural color on the lecture hall axis is distributed in muted and thick tones (Figure 8).

As American scholar Edmund Bacon noted (Bacon 1976), color contributes to the sense of continuity and spatial movement. The spatial impression stems from the interaction of color combinations in architecture and the environment, forming a continuous sequence, not merely an assembly of architectural colors (Cesar 2018). This is evident in the extraction of colors and the mapping of color scheme relationships in the pivotal nodal buildings along the Lecture Hall and Confucius Temple axes.

3.2.1. Color analysis of the axis of the lecture hall

The Lecture Hall axis encompasses five distinct nodes: Hexi Platform, the Main Gate, the Second Gate, the Lecture Hall, and the Imperial Library. The primary color scheme of buildings in each area forms the core of the sequence, while secondary colors in the surrounding environment are supportive elements. They interweave to craft a unique visual perception of the lecture hall axis sequence (Table 4).

The Hexi Platform acts as the commencement of the Lecture Hall axis. The interplay between natural color and the ground entails a prominent contrast in the color area and position relationship among the nodes. The building's increasing lightness from top to bottom accompanies hues with similar hue and purity. The resultant landscape impression of the node exudes a sense of natural freshness, where the spatial color sequence notably impacts individuals (Figure 9).

The Main Gate, positioned as the second node on the Lecture Hall axis, displays moderate area and color position contrast.The building showcases a low overall lightness, with ascending and descending lightness from top to bottom, along with comparatively similar hue and purity. This node's resulting impression is characterized by depth and sophistication, with a less pronounced impact on individuals regarding the spatial color sequence, akin to a musical prelude or overture (Figure 10).

Table 4. Architectural color analysis of yuelu academy lecture hall axis.

Architecture	Area Relationships	Location Relationships	Color Relationships	Brightness Comparison	Purity Comparision
Hexi Platform	Dominant-subordinate	Inclusive	Adjacent colors	Moderate	Moderate
The Main Gate	Primary-secondary	Semi-inclusive	/	Weak	Moderate
The Second Gate	Dominant-subordinate	Inclusive	/	Moderate	Moderate
The Lecture Hall	Dominant-subordinate	Inclusive	Contrast colors	Moderate	Moderate
The Imperial Library	Dominant-subordinate	Inclusive	Complementary colors	Weak	Weak

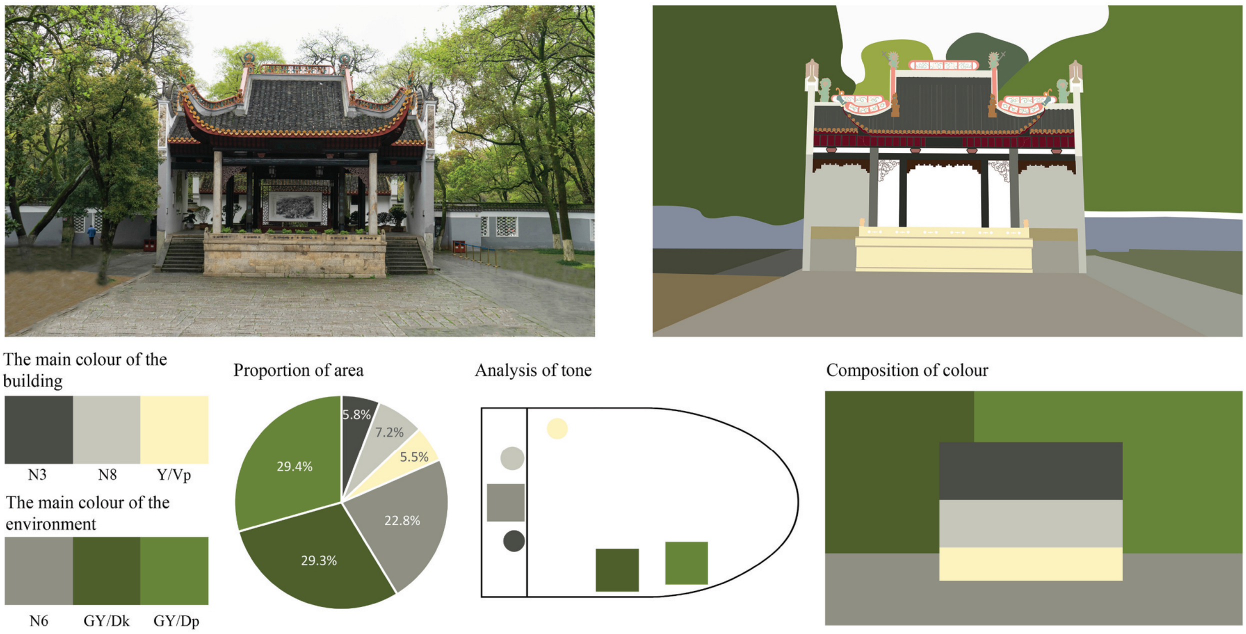


Figure 9. Color analysis of hexi platform.

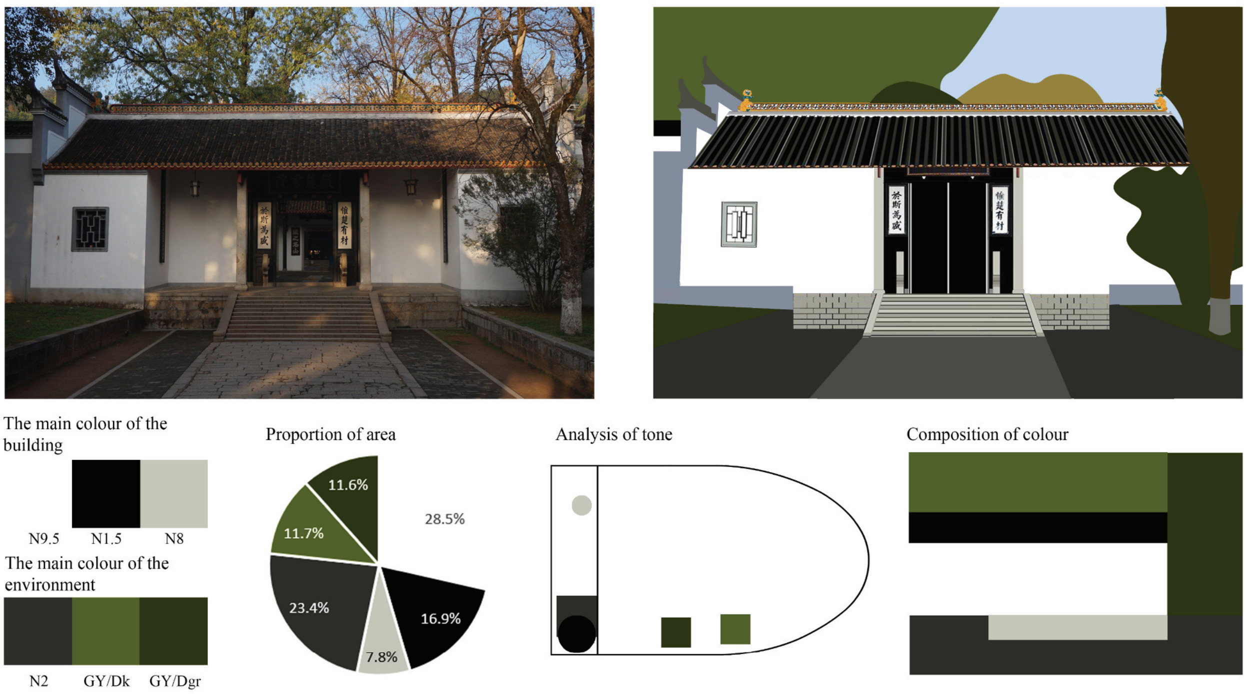


Figure 10. Color analysis of the main gate.

The Second Gate, as the third node, presents a distinct contrast in area and color position relationships. The building's lightness ranges relatively low and slightly increases top-down, featuring comparable hue and purity. The node evokes a general sense of natural freshness, sharing similarities to the Hexi Platform. It has a more pronounced influence on viewers than the Main Gate, functioning as a transitional link among the axis (Figure 11).

The Lecture Hall is the most critical node and presents strong contrast in both area and color position relationships. The building's overall brightness slightly increases from top to bottom, with similar hue and purity. However, noticeable hue disparities result in contrasting colors. The color sequence here significantly influences viewers and serves as the climax of the sequence, accomplished through vibrant hue contrasts, dominant areas, and strategic color placement in architecture (Figure 12).

The Imperial Library, situated at the end of the axis, exhibits a pronounced color area and position contrast. The overall lightness of the building shows an

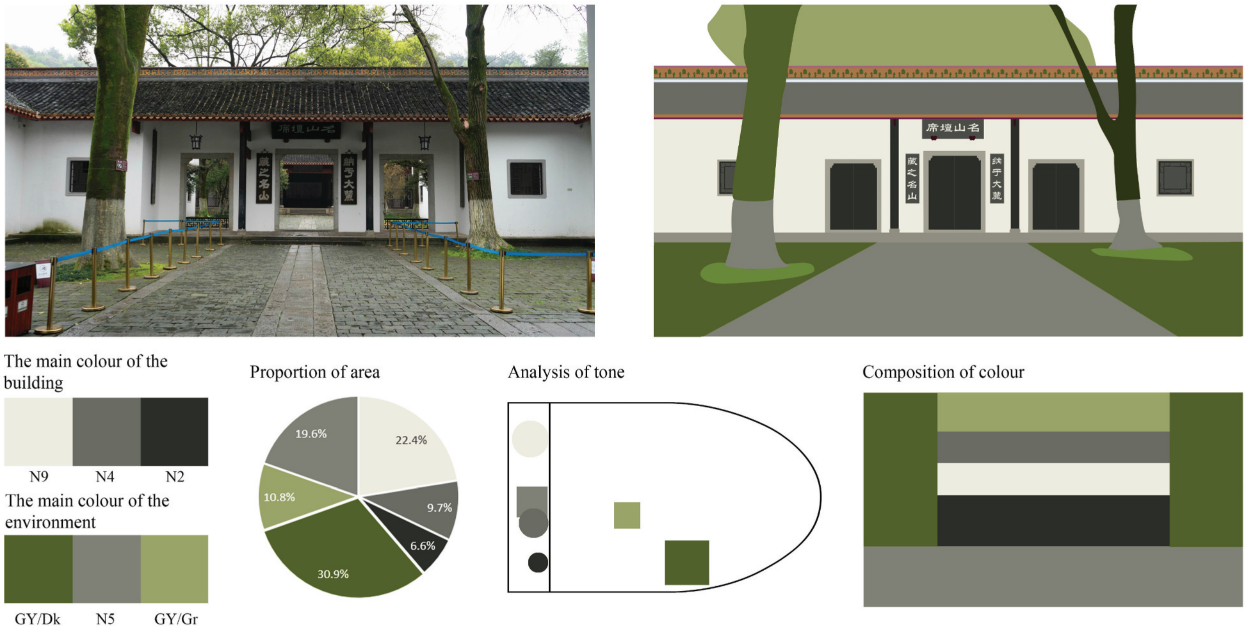


Figure 11. Color analysis of the second gate.

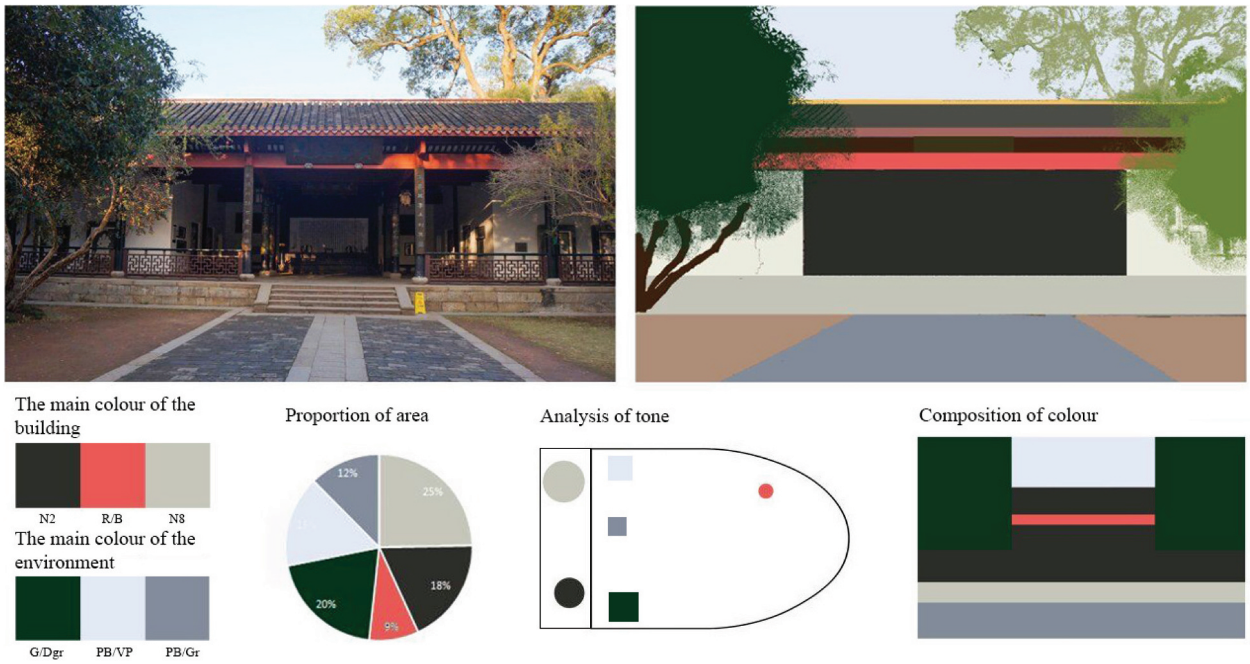


Figure 12. Color analysis of the lecture hall.

interphase arrangement of darkness and lightness, due to the tiered layout of the tile roof and glass windows. Contrasting hues and similar purity characterize the overall color scheme, achieved through the use of complementary colors. The proportion of the artificially created color of the Imperial Library is under half, the natural color dominates. In other words, the influence of natural color on humans peaks, marking the sequence's culmination as it gradually blends into the natural surroundings (Figure 13).

The lecture hall axis of Yuelu Academy exhibits a rhythmic and smooth succession of architectural colors. It begins with the remarkable Hexi Platform, proceeds to the relatively milder main gate, then intensifies at the second gate, culminates at the Lecture Hall, and concludes with comparatively natural hues most dominant at the Imperial Library. This sequence adheres to a pattern of gradually increasing intensity, ultimately returning to a more serene and gentle palette (Figure 14).

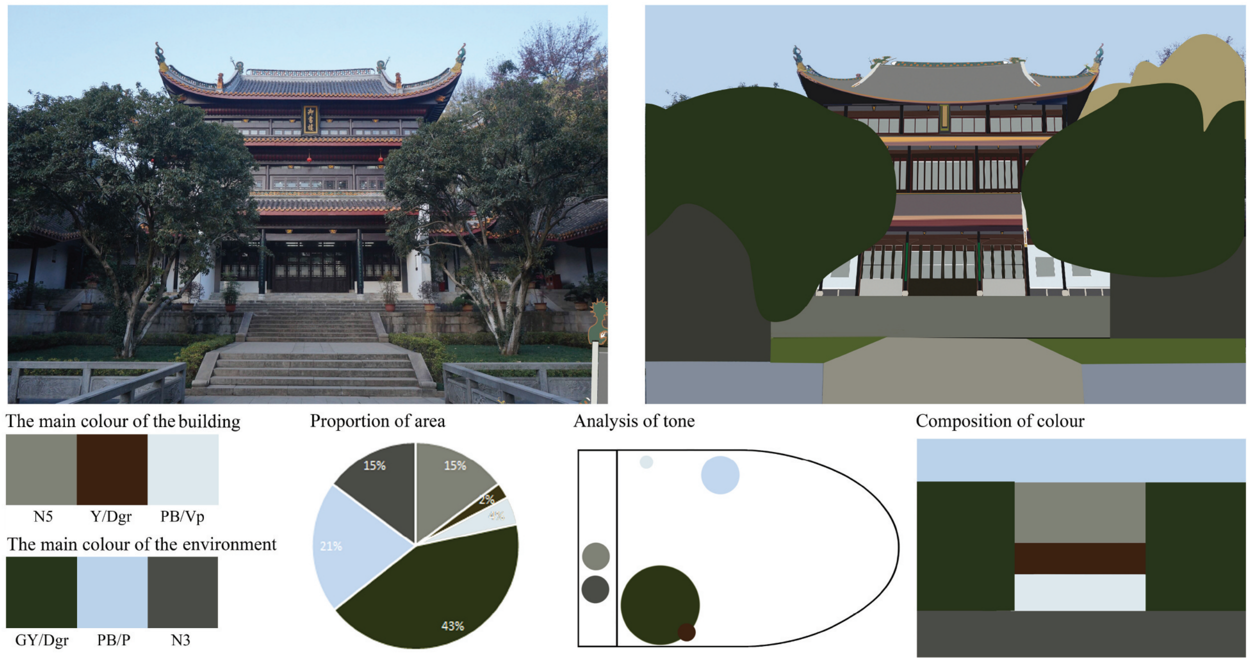


Figure 13. Color analysis of the imperial library.

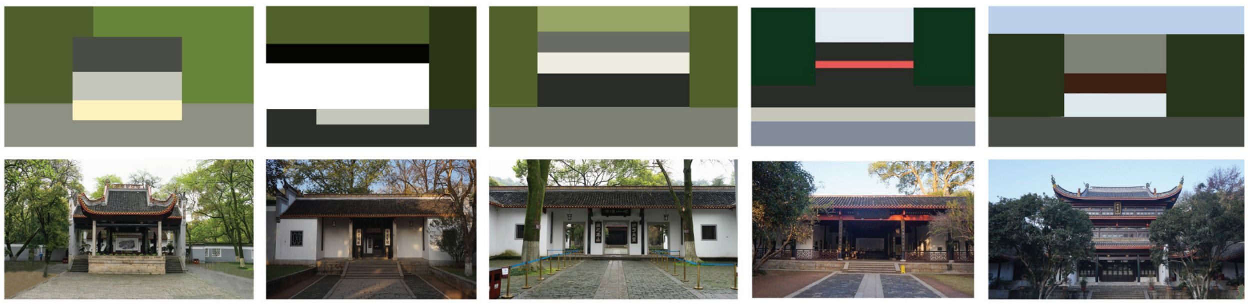


Figure 14. Color analysis of the colors spatial sequence of nodes on the lecture hall axis.

Table 5. Color analysis of the architecture along the axis of Confucius temple of yuelu academy.

Architecture	Area Relationships	Location Relationships	Color relationships	Brightness Comparison	Purity Comparision
Dacheng Gate	Primary-secondary	Inclusive	Contrast colors	Moderate	Weak
Dacheng Hall	Dominant-subordinate	Inclusive	Contrast colors	Moderate	Moderate
Chongsheng Temple	Dominant-subordinate	Inclusive	Complementary colors	Moderate	Weak

3.2.2. Color analysis of the axis of Confucius temple

Yuelu Academy's Confucius temple axis consists of three nodes: Dacheng Gate, Dacheng Hall, and Chongsheng Temple (Table 5).

Dacheng Gate is the first node in the Temple axis, featuring a medium area contrast and a robust color position contrast. The building exhibits declining overall brightness, transitioning from dim to intense as one moves top-down, with closely related hues and purity levels. The node imparts a classical and opulent design impression in its entirety. At the beginning of the Confucius Temple axis, the visual arrangement of colors has a moderate impact on viewers (Figure 15).

Dacheng Hall serves as the second node of the axis of Confucius Temple within Yuelu Academy, and it exhibits a strong contrast in both area relationship

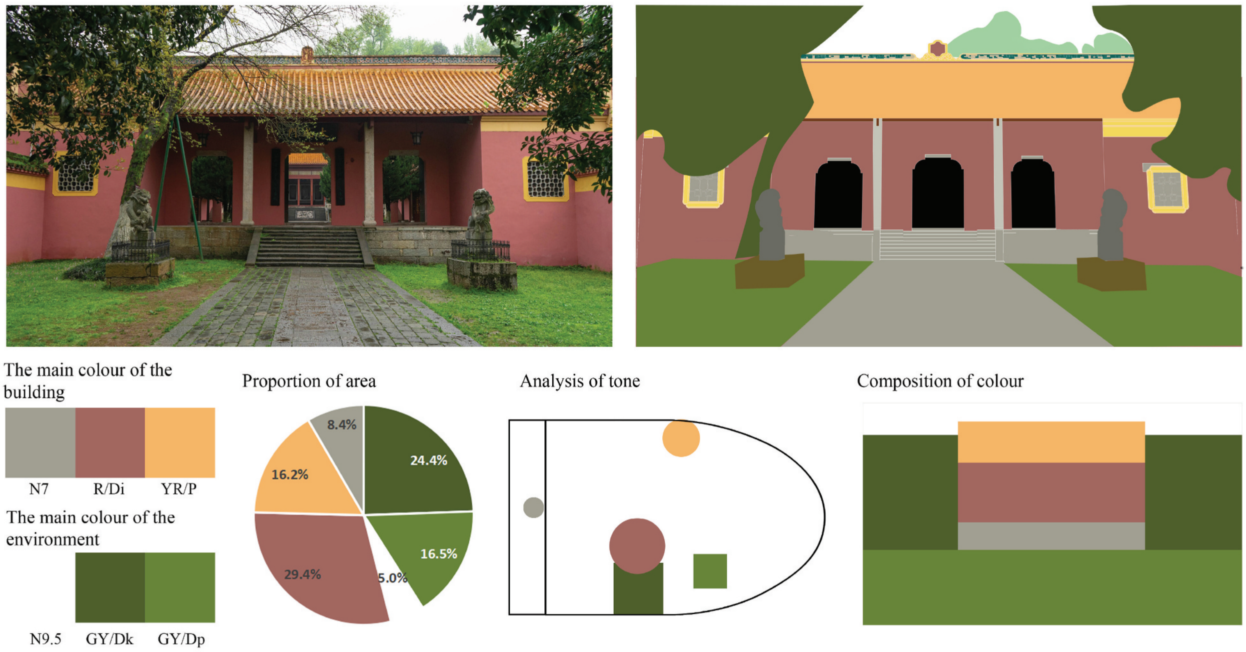


Figure 15. Color analysis of Dacheng Gate.

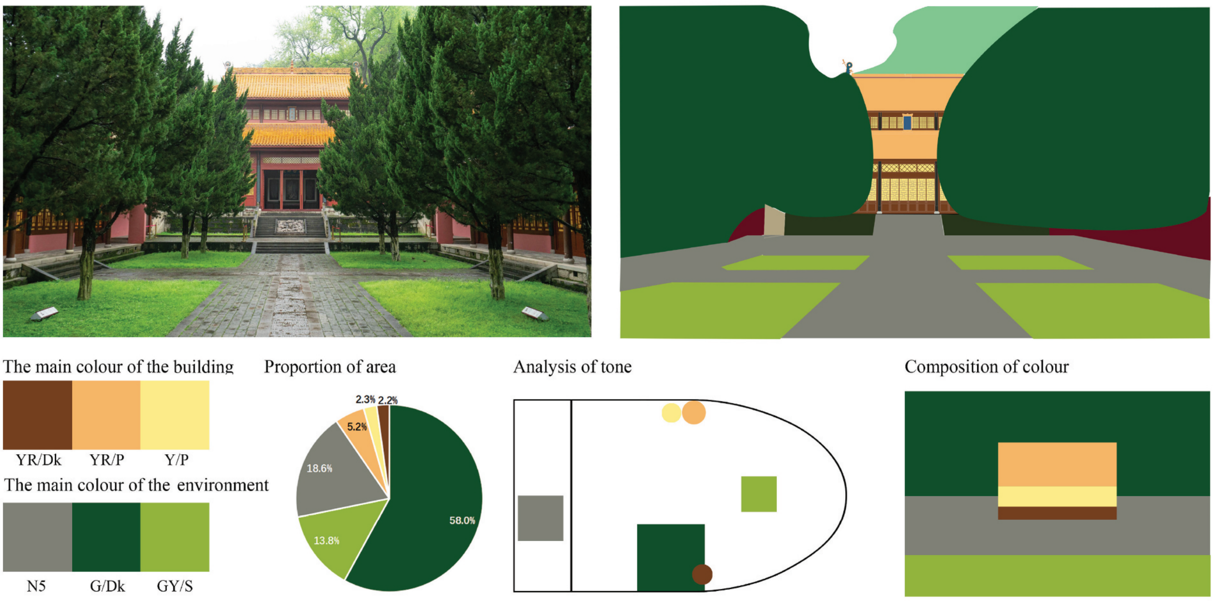


Figure 16. Color analysis of Dacheng Hall.

and color position relationship. The building's overall lightness decreases slightly from top to bottom, while the hues and purity remain relatively consistent. The spatial sequence of colors at this node has a significant impact on people, creating a small climax through medium contrast in hue, lightness, and purity, along with strong contrast in area dominance and subordination and location inclusion (Figure 16).

Chongsheng Temple, the last node of the Temple axis, demonstrates a significant contrast in both area and color position relationships. The building's overall brightness fluctuates with patterns of descent, ascent, and subsequent descent from its upper to lower portions. The color palette exhibits pronounced hue variations and incorporates complementary colors of comparable purity. Natural colors dominate in the

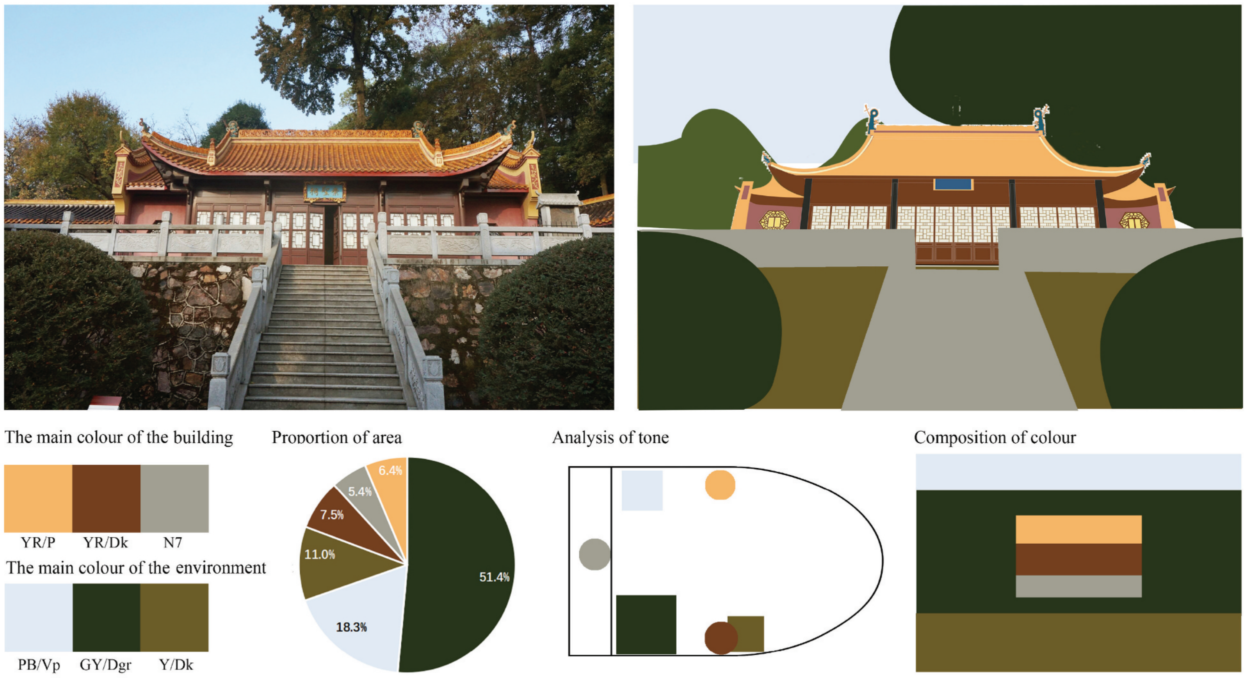


Figure 17. Color analysis of Chongsheng Temple.

node, significantly influencing the viewer and crafting idyllic color imagery associated with the spatial sequence. Situated amidst mountains and forests, the architecture marks the culmination of the Confucius Temple sequence and the axis as a whole (Figure 17).

The spatial sequence of the Confucius temple axis showcases clear contrasts in relationships, focusing on area and color placement. Dacheng Gate exhibits medium contrast with low brightness but similar purity, imparting a classical and luxurious impression to viewers. Dacheng Hall, being the second node, has a strong contrast with a similar hue and purity, coupled with reduced overall brightness, intensifying its impact on the viewer. Lastly, Chongsheng Temple exhibits a strong contrast in both area and color placement relationships with a decrease in overall brightness. It employs complementary colors and showcases a prevailing presence of natural hues. The sequence reaches a climax with the natural and idyllic imagery presented by the surrounding mountains and forests. The overall sequence concludes by integrating the building's colors harmoniously with the environment (Figure 18).

3.3. Color activation of the ancient architecture of yuelu academy

This paper aims to illustrate the practical application of color activation by through an illustrative example

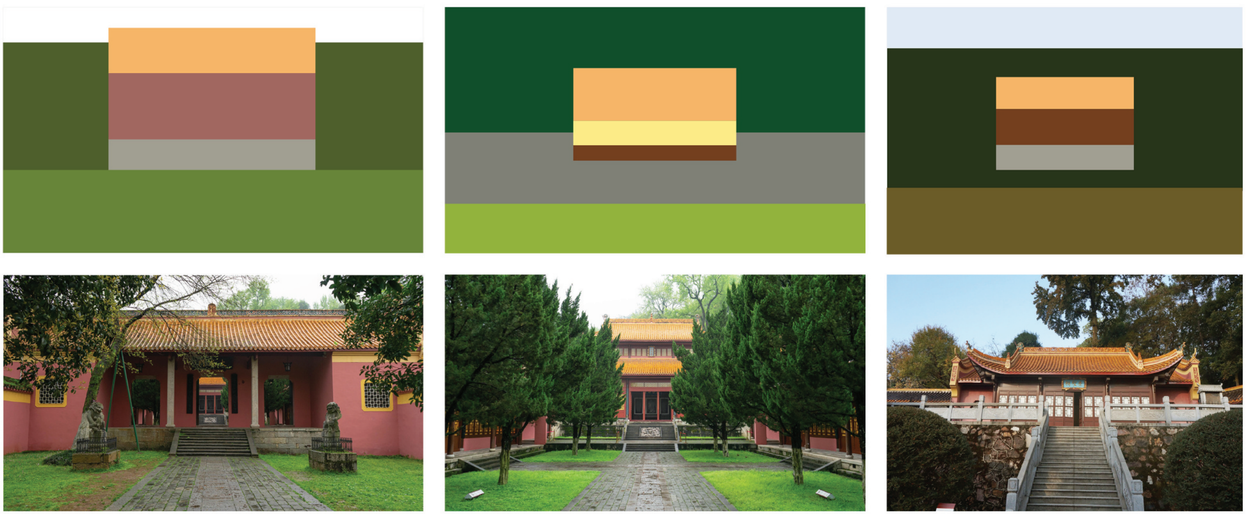


Figure 18. Color analysis of colors spatial sequence of nodes on Confucius temple.

implemented on Yuelu Academy's ancient buildings. There are two perspectives: the building's three-dimensional space and the two-dimensional design of creative souvenirs inspired by ancient architecture.

3.3.1. *Mesoscopic Three-dimensional Space*

To align with the color imagery of the Academy, color activation needs to be implemented to harmonize the Yuelu Scenic Area. However, the original shop design along Denggao Road prominently displays a highlighted V-tone orange color, which contrasts with Yuelu Academy's classical and refined color imagery. Therefore, the classic color scheme method is employed, drawing inspiration from Yuelu Academy Lecture Hall's "black-red-grey" color scheme. The V-tone orange is replaced with Dp-tone brick red, maintaining a modern design aesthetic that aligns better with Yuelu Academy's color imagery. Therefore, the core color application approach is implemented, utilizing the dark grey brick wall as the core color. This color, with the highest frequency and area coverage, replaces the original orange-red brick wall, conveying a more scholarly ambiance. Furthermore, the shop's current color design is top-heavy. Thus, the color relationship borrowing technique is employed, referencing Yuelu Academy's "three-stage" architectural structure and the distinct color relationship among the structures. The darkness of the steps at the bottom of the building is deepened, utilizing mid-blue-grey marble materials that resonate with the original roof color and simultaneously enhance the overall color composition (Figure 19).

3.3.2. *Microscopic two-dimensional planes*

This paper examines color prototypes at the micro level, focusing on architecture-inspired creative souvenirs as an illustrative case. Analyzing the existing creative products reveals that certain color shades are selected randomly, without considering integration with seasons and local attributes. Furthermore, the overall colors are elegant but lack distinctiveness. As an illustration, this paper employs Yuelu Academy weekly calendar postcards. These postcards showcase a month from each of the four distinct seasons, namely spring, summer, autumn, and winter, aligned with March, June, September, and December respectively (Figure 20).

The backgrounds and building silhouettes were adjusted based on the imagery of the academy's color imagery database. In the March weekly calendar, the yellow and yellow-green shades in the March weekly calendar were transformed to green, with reduced lightness and heightened purity, achieving a color palette that resonates with the season and region. This change mainly concerns the academy coloring and botanical colors, and being more in line with the "natural freshness" imagery. In the June weekly calendar, the initial purple and fuchsia segments were transformed to vibrant yellow and orange, achieved by elevating the colors' brightness and purity. Thus, the color scheme can reflect imagery like "classical and luxury", and incorporate core colors from the Confucius temple axis and the building materials' wood tones. In the September weekly calendar, considering elements like the "red wall" of Confucius Temple axis, the hue was shifted to red, enhancing color purity, while the silhouette's brightness was lowered to match the s4quare columns and purlins' hue of the building. In the December weekly calendar, to reflect imageries like "calm" and "delicate", and the hues of the academy sky and ground, the initial red and purple hues of the December weekly calendar

Figure 19. Color activation diagram of the surrounding buildings.

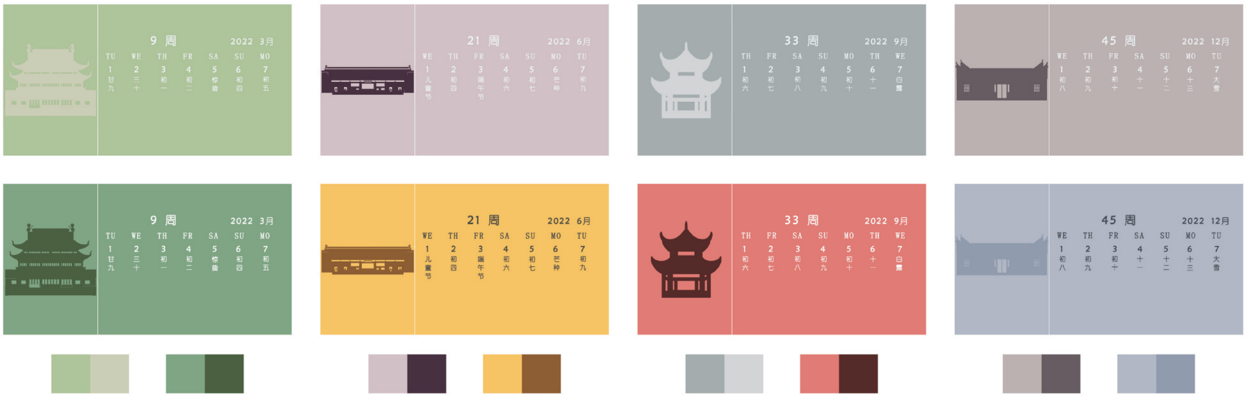


Figure 20. Color activation of ancient architecture-inspired creative souvenirs.

were transformed to a violet-blue shade, with adjusted brightness and purity to align with the academy sky and ground colors.

Yuelu Academy offers many creative souvenir products, yet, these items fail to authentically embody the Academy's essence. To revive the products' colors, the core color application, similar color substitution, and color relationship borrowing techniques were applied. These approaches effectively conveyed the academy's seasonal tones and distinct color attributes within the design.

4. Discussion

This research introduces a methodical approach to augmenting the conservation of ancient structures through the analysis and activation of color imagery, exemplified by Yuelu Academy. Leveraging the NCD system, the study systematically gathers, examines, and applies color data across various spatial scales. By integrating objective architectural features with subjective emotional dimensions, the methodology proposes an active engagement with heritage preservation, transcending static conservation practices.

While the study contributes significantly to the field, it is essential to recognize its limitations. Firstly, the study does not sufficiently account for the actual perceptions and needs of users, and empirical validation of the results is absent. What's more, the study's scope is limited in its exploration of color perception, as it predominantly relies on static color analysis data, such as photographs, without considering the color variations in architectural elements under different times of day and lighting conditions, as well as the dynamic interactions under varying seasonal and weather conditions. These factors are crucial for understanding color perception and developing effective preservation strategies.

To address these limitations, future research should integrate field surveys and user feedback to align color preservation strategies with visitor perceptions and needs. Additionally, dynamic color analysis methods should be employed to capture the temporal and lighting-dependent variations in building colors, as well as the interactions between building colors and the environment across seasonal and weather changes. Technologies such as drone photography, Virtual Reality (VR), and Augmented Reality (AR) could aid in this process, enhancing the practicality and adaptability of color analysis and ensuring it meets user needs while providing a comprehensive view of ancient building color preservation and revitalization.

5. Conclusion

This study examines the relationship between architectural color imagery and the preservation of ancient buildings using a comprehensive methodology. This includes collecting and analyzing color data, identifying key imagery nodes, and applying color activation techniques. The study emphasizes precise data acquisition and the use of chromatograms to discern critical imagery components. The suggested system involves tailoring color schemes to diverse functional needs and tiers. The ultimate aim is to present fresh perspectives on the preservation and advancement of ancient edifices by merging objective architectural elements with subjective emotional aspects.This study applies the methodology of "color information acquisition, color imagery analysis, and color activation and application" to the ancient architectural complex of Yuelu Academy.

The color analysis of Yuelu Academy's key architectural elements reveals a rich tapestry of hues and tonal relationships that reflect the academy's multifaceted functions and historical significance. The Entrance Gate, with its diminished saturation and brightness, presents a sophisticated and bright facade, characterized by a "dirty color scheme" with a strong contrast between white and black. The Lecture Hall's color scheme, dominated by colorless and warm tones, embodies a classical aesthetic, while the Imperial Library's harmonized color palette exudes a classical and exquisite imagery. Dacheng Hall's vibrant and thick color imagery and Lushan Temple's naturally vibrant hues further enrich the academy's visual narrative.

The analysis of the academy's axes showcases a dynamic progression of colors, with the Lecture Hall axis transitioning from the Hexi Platform's natural freshness to the climactic Lecture Hall and concluding with the Imperial Library's blend of artificial and natural colors. The Confucius temple axis, on the other hand, presents a sequence of contrasts, with Dacheng Gate's classical opulence, Dacheng Hall's medium contrast, and Chongsheng Temple's idyllic color imagery, all harmoniously integrated with the surrounding environment.

The paper concentrates on color activation for the adjacent building facades and creative souvenirs influenced by the academy's architecture. Specific refinements are suggested to enhance the products' alignment with the academy's color imagery. These findings underscore the significance of color in architectural heritage conservation, highlighting the need for a nuanced approach that respects the academy's traditional color schemes while adapting to contemporary visual preferences. The study's methodology, combining color information acquisition, imagery analysis, and activation application, offers a systematic framework for preserving and revitalizing the visual integrity of ancient buildings.

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