SCIRES it
SCIentific RESearch and Information Technology
Ricerca Scientifica e Tecnologie dell'Informazione
Vol 12, Issue 1 (2022), 121-132
e-ISSN 2239-4303, DOI 10.2423/i22394303v12n1p121

CASPUR-CIBER Publishing, http://www.sciresit.it

FINDING THE REAL COLOR-QUANTITATIVE COLOR EXAMINATION AND RESTORATION OF CHINESE HISTORICAL ARCHITECTURE

Yutong Jiang, Luke Li*, Yihua Zheng**

* Tsinghua University - Beijing, China.

Abstract

This study incorporates quantitative color examination and measurement into the study of visual performance of traditional Chinese architecture. It provides an objective and scientific way for generating color-restoration drawings that either reflect the "original" or "current" state of the building by looking for the extreme chroma color and calculating the average color. This method reinforces people's understanding of the true appearance of historic buildings and makes it possible to compare the similarities and differences of color schemes between different cases on an open and standard ground. This paper is supported by the Chinese National Key Research and Development Program of China - Research and Demonstration of Key Technologies for Scientific Cognition and Ontology Protection of Ming and Qing Dynasty Imperial Building Construction Techniques, Project Approval No. 2020YFC1522401.

Keywords

Polychrome decoration, color examination, color reproduction, heritage architecture.

1. *Introduction: Past research on the color of Chinese architectural polychrome decoration*

Polychrome decoration is an indispensable visual component of the traditional Chinese timber-frame structure. In addition to the practical function of preventing moths and insects (Lin, 1999), polychrome decoration largely determines the overall appearance of the building. As early as the Qin and Western Han dynasties, traces of paints had already appeared on wooden structures, and with the introduction of Buddhism during the Eastern Han Dynasty, all the way to a flourishing development in the Northern and Southern Dynasties, the decorative motifs and colors, especially on religious buildings were greatly enriched, and by the Tang and Song dynasties, high-class wooden buildings were described by ancient texts as "fully decorated"[1]. The image of building in Dunhuang's Tang Dynasty murals, as we see today, is almost entirely painted red, with richly colored patterns on the columns and between the bucket arches (*dougong* 斗栱). The main hall of Kaihua temple, a wooden structure dating back to Song Dynasty, remains a fully decorated inner space, creating a glorious visual effect echoing with the colorful wall paintings. In the Ming and Qing dynasties, the form of decoration tended to be highly standardized and regularized. As the largest surviving architectural complex in Beijing, looking at the Forbidden City from above, under the roofs of yellow glazed tiles, there can be seen thousands of vermillion columns and windows, as well as bucket arches and architraves painted with blue and green. It can be said that the development of color and visual appearance is an integral of the history of traditional Chinese architecture (Sun, 2006).

The study of Chinese architectural polychrome decoration in the past few decades can be broadly divided into three aspects: physical materials, cultural significance, and visual properties (Li & Shi, 2021) with the latter focuses on the external appearance of the color coating and the way the observer perceives it. The external appearance can be further subdivided into two categories: colors and patterns. In previous studies, scholars have discussed in detail the characteristics and the origin of the motifs, the rules of the composition, and the painting techniques.

[1] In YingZao FaShi, an imperially commissioned Northern Song building manual, polychrome decoration was discribed as "vivid and magnificient, like the patterns on brocade silk".

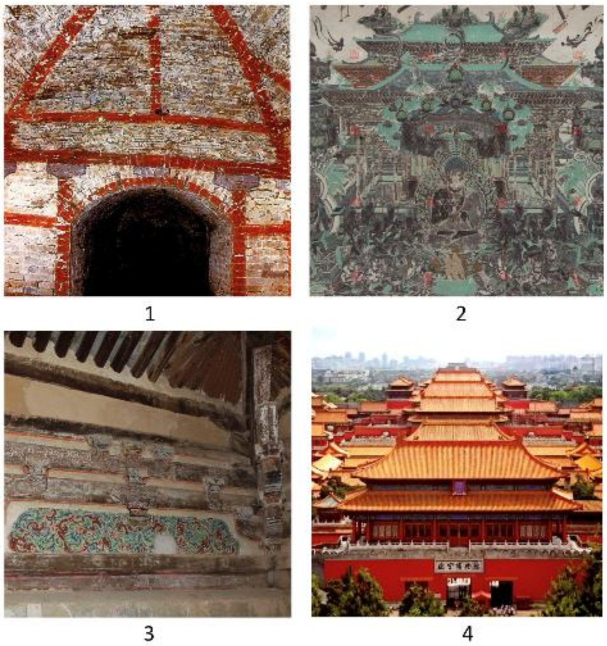

Fig. 1: The Evolution of Polychrome Decoration of Traditional Chinese Architecture: 1: Yin Tun Mural Tomb, Luoyang, Henan Province, Xin Mang Dynasty (A.D.9-23)
2: Mogao Grottoes Cave 217， DunHuang, Gansu Province, High Tang Dynasty (A.D.713-766)
3: Main Hall of Kaihua Temple， Gaoping, Shanxi Province, Song Dynasty (A.D.1100)
4: The Forbidden City, Beijing, Ming to Qing Dynasty (A.D.1400-1900)

However, as for the study of color, most of the discussions have been a mere generalization of the hue or a brief description of its effect. General description may lead to wrong interpretation and even wrong perception. An interesting example might be how people from early 20th century illustrated a set of polychrome decoration drawings of *Yingzao Fashi* from 12th century. Since the original illustration was colorless, with only the name of the color labeled to the according pattern, it was hard to envision the colorful version. In 20th century, Tao Xiang redrew and colored these illustrations based on his own understanding. His work was then widely accepted as the “real appearance” of polychrome decoration of 12th century building, which later turned out to be unrealistic as the discovery of Kaihua temple, a well-preserved 12-century tim ber structure with polychrome decoration.

The ostensive nature of visual images means that the study of such material relies heavily on the "presence" of the images.

Fig. 2: Top: the colorless illustration in the original Yingzao Fashi. Middle: the illustration by Tao Xiang, 20th century. Bottom: Photograph of polychrome decoration of the similar pattern, Kaihua Temple, 12th century

That is, while the researcher may describe the image in words, his or her opinion will be less effectively conveyed if the reader is ignorant of the image (Baxandall, 1985).

The pesence of the image allows the reader to better understand the idea through the cross-reference of words and the subject. Photographs are the most objective and authentic first-hand record.

For example, Su Bai, a famous architectural historian of Peking University, published a large number of on-site photographs of the Baisha Song Tomb (白沙宋墓) in his book of the same name in 1950s, in order to corroborate as much as possible with his textual descriptions (Fig. 3, left).

Not only his study is by now still the most inclusive on this particular case, he also explored the methodology of invesgating underground architectural remains by bringing up the term Art Archaeology. However, there are still a large number of ancient buildings remain overground with serious damage of their structures and aging of the colored surfaces, making it hard to imagine the original appearance.

1 2 3

Fig. 3: Photographs and color-restoration drawings of different cases. 1: Photograph: Bai Sha Song Tomb by Su Bai 2: Color-restoration drawing: Luo Ancestral Hall, presided over by Zhang Zhongyi. 3: Color-restoration drawing: Kaihua Temple, by Yutong Jiang (author)

These cases not only need to be represented by photos, but also requires other means of representation in order to get an idea of the look without damages. Color-restoration drawing not only illustrates a more complete decorative appearance, but also reflects researcher's own understanding of the subject. For example, in the 19th century, there was an intense discussion in Europe about whether classical architecture was purely white, as described by Winckelmann "noble simplicity and quiet greatness" (Kruft, 1994), or it was rather pretty colorful, in which different scholars presented very differentiated color restoration schemes of the same Aphaea temple based on their own understanding and opinions (Harrer, Li, & Jiang, 2017) (Fig. 4).

This interesting occasion shows that color-restoration drawing is not only an expressive technique, but also an important result of the research. Since digital techniques were not yet popular in the early days, scholars drafted and hand-painted most of their works as shown in Fig. 3 middle. With their subdued color and fine details, these drawings can be considered works of art with ornamental value in their own right. However, the authors of these works did not elaborate on the criteria and process for the selection of colors. In fact, the use of color in hand-painted drawings relies heavily on the draftsman's own subjective visual experience and perceptual judgment and is a creative process that's almost impossible to replicate.

Fig. 4: Eastern pediment of the Aphaia Temple. Left: Reconstructed by Cockerell. Right: Reconstructed by Garnier

Therefore, it is difficult to quantitatively understand the similarities and differences between these restored works and the originals, and we cannot obtain an objective understanding of the appearance of the original architecture through these drawings.

Now more and more researchers have been using digital means to produce the restoration drawing, but without a standard color investigation procedure, problem still remains that how do we represent the "accurate" color appearance of the architecture.

For example, in Fig. 5, image on the top left was the color reconstruction drawing of Kaihua temple by the author, and the bottom one was of the same place by another researcher, it is very obvious that the choices of color and the final outcomes are quite different, and they both vary from the photo, which reflects the current condition.

By briefly reviewing the history of color restoration in the study of Chinese architecture, it can be inferred that a set of scientific procedures have not yet been established for the investigation of polychrome decoration and the selection of color in restoration work.

The importance of such a methodology is not only to quantify more scientifically the color characteristics of a particular architecture case, but also to make possible the comparison of color differences between cases, and to place all kinds of historical colors in an open, standard and scientific color system.

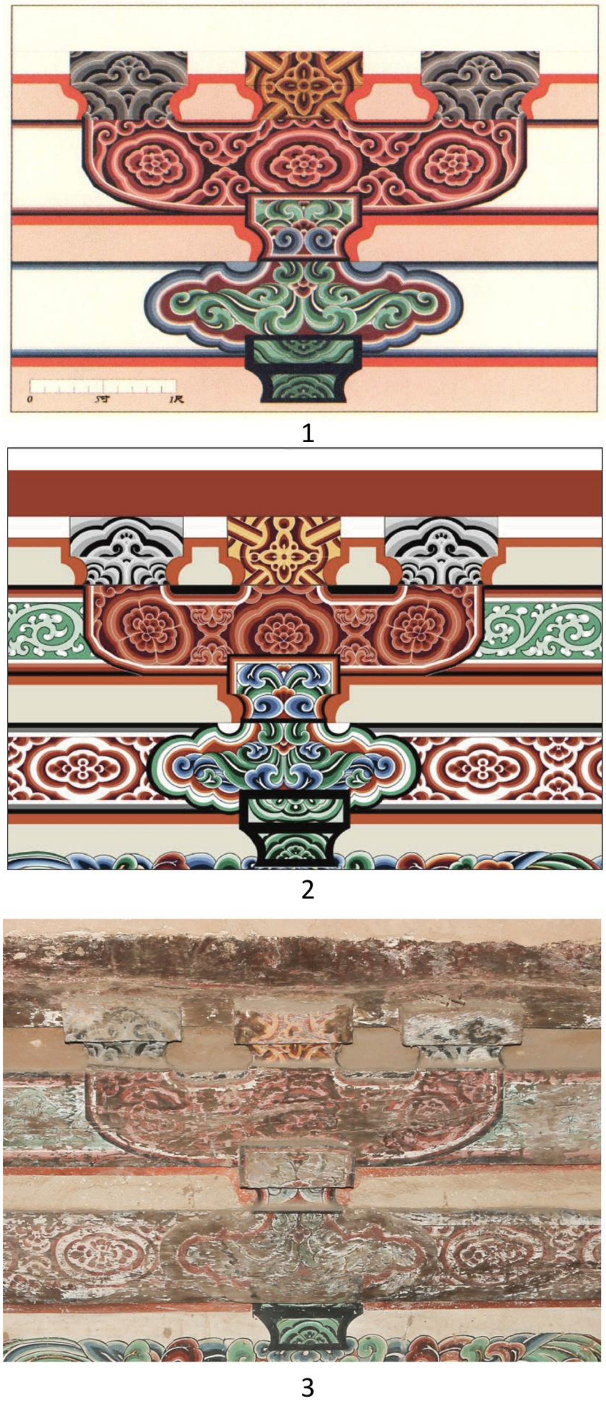

Fig. 5: Digital Color-reconstruction drawing and photo of Kaihua Temple. 1: Reconstructed by Tong Chen. 2: Reconstructed by Yutong Jiang(author). 3: Photograph

2. *Experimentation and Exploration: Color Survey of Qing-style Wooden Model in Tsinghua University*

This study attempts to explore the quantitative color examination method and color restoration criteria for the polychrome decoration of traditional Chinese architecture through various aspects such as image recording, chromaticity measurement, and chromatographic analysis.

Fig. 6: Top: The model now. Bottom: The model in late 20th century, with professors sitting in front looking at restoration drawings of polychrome decoration in Song style

2.1 Overview of research subjects

The research subject is a L-shape timber-frame model located on the north side of the first floor of the Department of Architecture Hall of Tsinghua University, Beijing, China, covering an area of about 3.2x2.6 meters (Fig. 6 top). The Qing-style polychrome decoration is distributed all over the surface of the model. The type of decoration is called "Xuanzi" (旋子) whose literal translation is volutes (Fig. 7). The distinctive pattern is the set of round volutes on both ends of each beam using gold as the primary pattern outline, incorporating blue, green and red as the three major colors. It is a high-class polychrome decoration form that can

Fig. 7: Polychrome decoration of the model

only be used in imperial buildings back in Qing dynasty. According to an old staff of the deparment, this model was assembled during 1950s as a teaching aid to demonstrate how traditional wooden structure was put together and the basic rules and characteristics of the decoration (Fig. 6).

2.2 The basic procedure of color survey

On-site Data Acquisition (see Fig. 8)

Overall Photography: Used to obtain the general color effect of the study subject and its surroundings. Since this model is located indoors, we applied D65 standard light source to unify color tempretures among pictures. However, it's not possible to always have ideal lighting condition, especially lots of ancient structures are in remote areas without electricity. Thus, it's important to conduct color correction. This study used Color Checker Passport by Xrite to later calibrate the white balance in digital software, thus photos taken with different lighting conditions can be adjusted as with closer color tempreture.

Micro Photography: Color appearance, to a great extent, is determined by the type of pigment and the craftsmanship through which colors are applied. Micro photography allows the researcher to obtain morphological informations of the color coating, such as the size of pigment particles, whether one pigment is superimposed on another or whether there is a mixture of pigments. These phenomenons are difficult to observe with visual inspection but are essential for understanding the craftsmanship of the polychrome decoration.

Visual color evaluation: This prodecure can be regarded as a qualitative color inspection on a general scale. By comparing certain colors on the study subject with standard color swatch cards published by professional color institution[2], and identifying one color on the swatch card that's closest to the target color on the subject, we were able to locate a stable and standard color to describe the relatively uneven visual appearance of a certain color on the structure. However, this process is still subjective since each person may have different color sensitivity and lighting condition may vary from time to time, we introduced scientific divices to measure color qualitatively as described as follows.

Chromaticity measurement: There are two types of chromaticity measurement instruments adopted in this study, the RAL COLORCATCH NANO by RAL (Switzerland) and the CM 2600d spectrophotometer by Konica Minolta (Japan). These two devices work on different principles. NANO uses photogrammetry, a photograph is taken with 9 built-in D65 Led lights and the color components in the photograph are analyzed. It operates with smartphones. Researcher are able to further pick a spot that can be as small as 0.36mm in diameter on the microphotographs appeared on the screen.

Thus, it allows the researcher to idenfity the less discolored areas and exclude the more contaminated areas, highly applicable for mottled color surface. The CM 2600d spectrophotometer emits a light source in a wavelength of 360nm-740nm, and after the light passes through the color sample being examined, some of the light is absorbed, and the remaining light is reflected back into the instrument by the filtered color grating, from which a more comprehensive spectral data can be calculated.

Spectrophotometer results are more stable than NANO and can also be a good assessment of the phenomenon of metamerism. However, this device has a caliber of 8mm in diameter, making it very hard to exclude color areas with bad conditions and can only generate an average color in the measurement aperture range. It is not possible to further manually select points as in the Ral Nano color picker and is therefore more suitable for measuring uniform color surface.

[2] This study used CBCC (Chinese Building Color Card) pubulished in 2002 by Chinese Standardization Administration and General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China. It contains 1026 colors and is currently the most authoritative national color standard. It complies with GB/T 18922-2002 Methods of Color Specification for Architecture, a national color standard published in 2002.

Overall picture with Color Checker Passport under D65 Light

Visual Color Evaluation with Standard Color Cards

Micro Photography of Blue Coating

Chromaticity Measurement(CIE L*a*b)

Fig. 8: On-site Data Acquisition Process

Data processing and color swatch generation

Several concepts need to be briefly explained in order to scientifically generate a set of color for the color-restoration drawings: The Original State, the Current State, and the "Ideal Model".

The Original State is the state of the building when it was just built. There would be no major contamination and fading of the polychrome decoration since everything wes freshly painted.

The Current State is the state of the building observed by the modern researcher. After a long period of sunlight and weathering, there are different degrees of fading and flaking on the surface of the color coating. Most of the existing traditional Chinese wooden buildings are in this state, and they may appear worn-out if not properly protected.

The Ideal Model, on the other hand, is a state that has never existed in reality and exists only in the minds of designers or craftsmen, strictly adhere to the various rules and regulations, and is a perfect state that eliminates all kinds of errors and discrepancies in construction.

The color-restoration drawing is able to illustrate each of the above three states. For example, the restoration of the Luo Ancestral Hall (Fig. 3, middle) is closer to the visual effect of the current state because it was rendered just as the researcher perceived it, while the restoration of the Kaihua Temple (Fig. 3, right) tries to approach the ideal model of the polychrome decoration by using more saturated colors. This study measured four major colors of the model: blue, red, green and gold; as well as 3 minor colors: brown, orange and purple. For each major color, 30 samples were taken from 10 different locations; and for each minor color, since it only appears on a small area of the model, 10 samples with 2 different locations were taken. We conducted an overall 150 color measurements in total. The CIE L*a*b* chromaticity coordinates of all the colors on the study subject are measured and recorded. CIE L*a*b* is an authoritive color space with L representing luminance, a representing human vision from red to green, and b yellow to blue. This can be understood as a perceptually uniform color space with numerical differences corresponding to the actual color difference. Depending on the purpose of the drawing, the criteria for the color swatch differs accordingly. From the L*a*b* chromaticity data obtained through on-site investigation, two different types of color swatches can be generated.

Average color: The average color of all color samples of the same hue.

Average color reflects a more stable and conclusive appearance of a certain color presented on the polychrome decoration. It is closer to the comprehensive effect that the human vision perceives when observing that color.

Extreme chroma color: The aging of pigment coatings may have both oxidation of certain pigment components and fading from years of exposure to UV light. The former will darken or blacken the pigment layer, while the latter will make the pigment layer lighter, but both will reduce the chroma(saturation) of the color coating (Fig. 9). Thus, color sample with higher chroma value can be considered closer to the original state.

These two types of color, the average color and the extreme chroma color can be used to illustrate “the Current State” and “the Original State” color-reconstrution drawings respectively.

Data identification: The two color-measuring instruments used in this survey have different measuring calibers. The Konica Minolta CM 2600d spectrophotometer has higher stability and larger caliber (8 mm dia.) and performs better with larger and more uniform color surface.

The RAL COLORCATCH NANO has smaller caliber (0.36-8mm dia.), making it easier to measure small color patches with mottled colors.

Fig. 9: Picture from Mogao Grottoes-Cave 254-Main Chamber-North Wall (Northern Wei Dynasty) where the original vermilion turned from red to black due to oxidation

In addition, some pigments use oil3 as the substrate while others use glue4, resulting in different glossiness of the color coating.

Therefore, it is necessary to decide SCI (Specular Component Included) or SCE (Specular Component Excluded) data according to the glossiness of the target color sample. For a more visual observation of the color data characteristics, we converted L*a*b* to LCH data, where C stands for Chroma and H for Hue. The formulas are as follows:

$$C = \sqrt{a*^2 + b*^2}$$
$$H = atan_2(b*, a*)$$

Taking color blue as an example, 33 samples are distributed in a H-C diagram (Fig.10) where it's easy to read that the range of hue is around 30° indicating that the color samples observed on-site as "blue" are consistent with the actual chromaticity value result.

Excluding outlier: Firstly, color samples that are obviously contaminated or discolored will be excluded from the data. Secondly, any color date with △E2000>4 from average will also be excluded. Since the color appearance of polychrome decoration can be affected by artisan's hand movements, its uniformity is naturally lower than modern spray printing product, so the color difference tolerance is relatively relaxed compared with GB/T 15608 (Chinese color system standard), where the acceptable △E2000 should be less than 3.

Determining the number of shades: The main technique of applying color in Qing style polychrome decoration is called "receding shades" (*tuiyun* 退晕). This technique has quite a history and dates all the way back to Song Dynasty (12th Century). The distinctive feature of this technique is overlaying 2-3 shades of the same color with progressive luminance that forms a natural and harmonious color transition in order to imitate the effect of light and darkness on the surface of an object (Fig. 11). In Figure 12, the luminance of these blue colors clearly shows three gradients: the darkest, the middle and the lightest, indicating that there are three layers of "receding shades" on the study subject and each shade can read an extreme-chroma color and can calculate an average color. After the above processing and analysis of chromaticity data, the average color and extreme chroma color of all main colors (including different shades) can be generated separately as two color-swatches. They are applied to color-restoration drawings of "the current state" and "the original state" respectively (Tab. 1-2).

Tab. 1 Chromaticity Values of Extreme Chroma Color

Extreme Chroma Color			
	L	a	b
Blue1	14.4	21.9	-49.7
Blue2	36.4	3.1	-23
Blue3	58.8	0.9	-11.4
Green1	26.6	-19.3	5.1
Green2	46.3	-12	7.7
Red	17.7	33.2	16.9
Gold1	62.1	3.6	32.3
Gold2	68.3	6.5	26.2

Tab. 2 Chromaticity Values of Average Color

Average Color			
	L	a	b
Blue1	17.18	9.95	-35.72
Blue2	41.81	1.83	-15.84
Blue3	60.57	1	-8.27
Green1	36.1	-25.5	12.3
Green2	44.1	-10.1	8.4
Red	33.1	31	15.6
Gold1	85.6	7	29.3
Gold2	83.9	4.8	27.9

3 Natural vegetable oil such as Tung oil, or synthetic resin such as varnish.

4 Traditional chinese architecture more oftern uses animal glue such as fish glue, bone glue or leather glue.

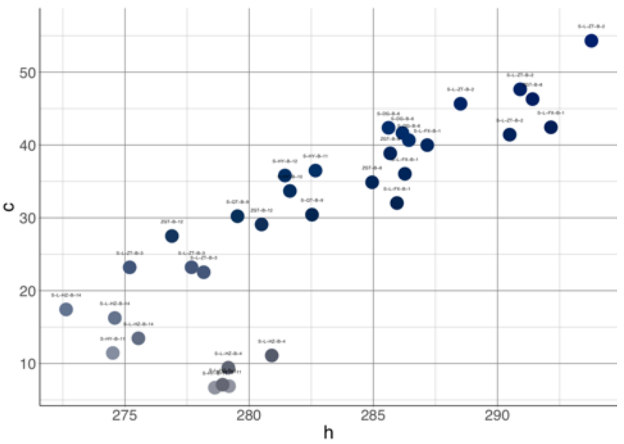

Fig. 10: Chroma-Hue chart for all blue samples

Fig. 11: Details of the Decoration

2.3 Further interpretation of chromaticity data

In addition to generating sets of color swatch for color-restoration illustrations, this process of color examination and analysis also helps to detect color patterns that are difficult to detect with the naked eye, as well as color phenomena that may be related to the craftsmanship, in order to better understand the overall design of the structure.

Chromaticity Pattern

Taking blue as an example, from this L-C diagram of average color and extreme chroma color (Fig. 17 and Tab. 3), several patterns can be identified.

The luminance of all extreme chroma colors is smaller than the average colors by around 5, which confirms that the former is less faded and discolored than the average.

The darkest shade blue has the largest sample size (21), following the middle shade (12) and the lightest shade (6). And the color differences between the average and the extreme of the same shade △E2000 are 6.9, 6.1 and 2.7.

It may be generalized that the greater the size of the samples, the further the distance between the extreme chroma color and the average color.

This is perhaps because the greater the number of samples measured, the closer the average color is to the overall appearance of that color, while at the same time the chances of measuring a purer chroma extreme color will be higher.

It can be assumed that when the number of samples increases to a certain level, the difference between the average color and the extreme chroma color will stabilize to a certain amount that may reflect the degree of discoloration of the color of the polychrome decoration.

Tab. 3 Average and Extreme Chroma Color of the Three Shades of Blue

Name	L	a	b	ΔE_{2000}	Sample Size
Blue1-Ave	14.4	21.9	-49.7	6.9	21
Blue1-Ex	17.18	9.95	-35.72		
Blue2-Ave	36.4	3.1	-23	6.1	9
Blue2-Ex	41.81	1.83	-15.84		
Blue3-Ave	58.8	0.9	-11.4	2.7	3
Blue3-Ex	60.57	1	-8.27		

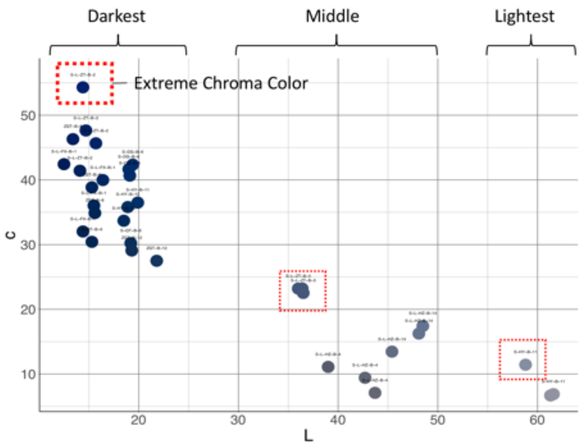

Fig. 12: Luminance-Chroma chart for all blue samples

Color-restoration with Extreme Chroma Color

Color-restoration with Average Color

Orthograph from 3D laser scanning

Fig. 13: Color-Restoration Works

The three shades of blue are basically equidistantly distributed on the luminance axis, about 15 for the darkest shade, 40 for the middle shade and 60 for the lighter shade. In other words, each shade can be clearly distinguished by its appearance, and the three shades can form a continuous transitional effect.

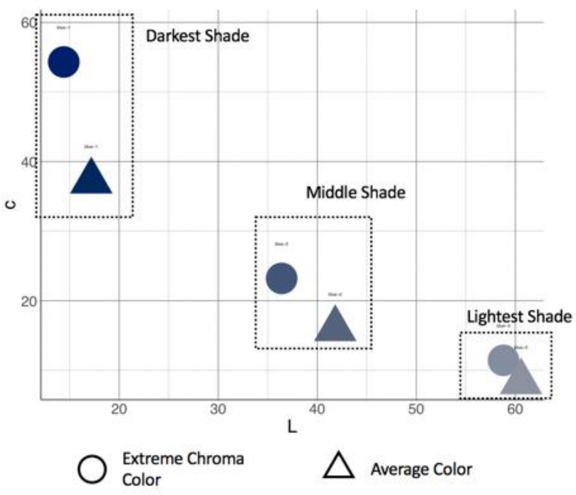

Fig. 14: Luminance-Chroma Chart of Blue

Implication regarding Craftsmanship

There is an iconic technique in Qing dynasty polychrome decoration known as **Gelled Patterning with Gold Leaf** (*lifentiejin* 沥粉贴金). The basic process is to mix a kind of paste from glue and earth powder, outline a raised pattern through the tip of the tube stuffed with the paste (Fig. 15), and then gild the pattern with gold leaf (Fig. 16).

Most patterns in gold of polychrome decoration are created by this technique. However, there also exists the technique of applying gold leaf or gold powder directly to the surface of the structure without gelled patterning, taking up a smaller portion of the decoration.

These two kinds of gold-related techniques can both be seen on the study subject. According to the SCE chromaticity data (Fig. 17), the gold without gelled paste has higher lightness than the gold with gelled paste.

This phenomenon may be explained through the traditional craftsmanship. There are two types of gold leaf commonly used in traditional polychrome decoration, one is Pure Gold (*kujin* 库金), the other is Pink Gold (*chijin* 赤金).

Pure Gold contains up to 98% gold, while Pink Gold only contains 74% and the rest is mainly silver. The difference in composition causes Chijin to be visually whiter. Generally speaking, these two materials are used at the same time on a traditional structure to create a glorious and diverse visual effect.

Fig. 15: Outline the raised pattern through the tip of the tube stuffed with the paste

It can be speculated that Kujin with higher purity might be used in gelled patterning gold while Chijin might be applied to larger areas without gelled paste (Fig. 11).

3. Further Discussion – Finding the "ideal model" through rediscovery of the original craftmanship and restoration of the original pigment

This paper explores the procedures for quantitative color examination of the polychrome decoration of Chinese heritage architecture.

Based on refined color-measuring methods and quantitative control of color data, and with a more conscious choice of the color swatch for color-restoration drawing, this process not only helps researchers to form a more scientific perception of the visual color performance of the architecture, but also leads them to further study the craftsmanship by revealing a certain pattern in the chromaticity data.

This research method focuses on the visual characteristics of the polychrome decoration of Chinese heritage buildings.

Two sets of colors, the average color and the extreme chroma color, are considered reflecting the current and the original state of the building.

However, while the extreme chroma colors are identified by looking for areas where the pigment is less discolored, in order to resemble as much as possible the color appearance of the building as when it was just finished painting, there is still a distance from the "Original State" to the "Ideal Model".

In order to more accurately restore the ideal color effect of the polychrome decoration, it's necessary to acquire as accurately as possible in detail the materials used in the painting, including types of pigments, glues and other auxiliary materials, as well as the order and process of painting.

Fig. 16: Gilding the pattern with gold leaf

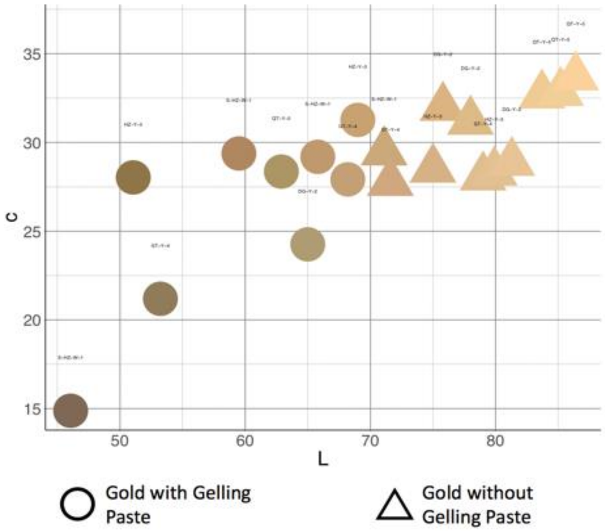

Fig. 17: Luminance-Chroma Chart of Gold

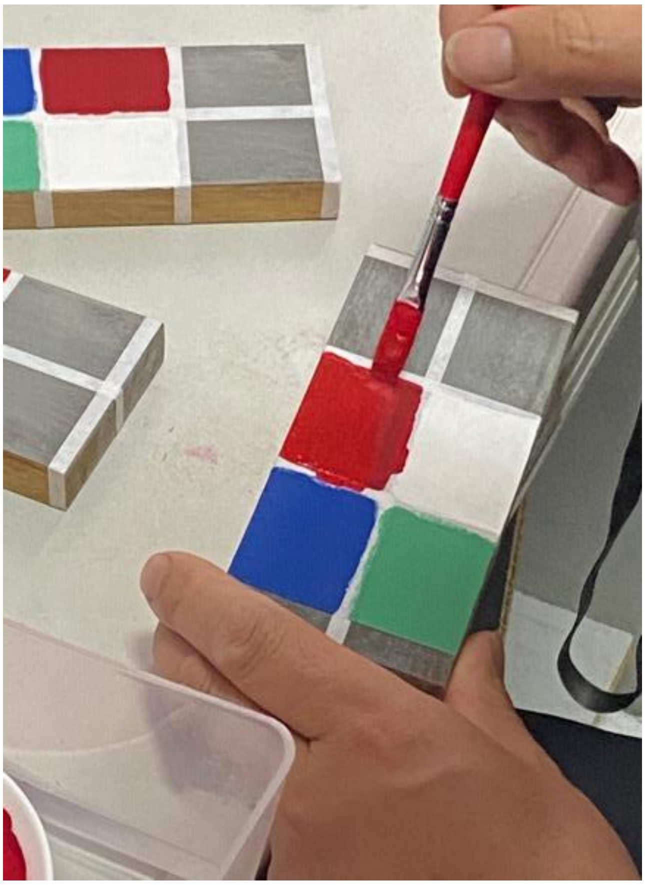

Fig. 18: Experimenting on Color Sample

This information can be obtained by scientific and technical means. For example, with on-site microsampling, X-ray fluorescence analysis (XRF) allows researcher to understand the elemental composition of the pigment, polarized light microscopiy (PLM) and cross-sectional microscopiy helps to identify the coloring sequence and types of substance.

Based on the understanding of material and craftsmanship, we can obtain a complete set of "ideal color scheme" by experimenting on a series of color sample applying original pigments and procedure and measuring its chromaticity values (Fig. 18), which can be used to produce the color-restoration result of the "ideal model" of the heritage architecture.

REFERENCES

Baxandall, M. (1985). *Patterns of intention: On the historical explanation of pictures*. London: Yale University Press.

Bian, J. (2013). *Paintings and Polychrome Decoration of ancient Chinese buildings*. Beijing, China: China Building Materials Industry Press.

Harrer, A., Li, L., & Jiang, Y. (2017). Repainting Antiquity: The 19th-Century Architectural Polychromy Debate Seen Through "German" Eyes: Hittorff, Semper, Kugler and Their Generation. *World Architecture* (11), 80-88+122.

Kruft, H. W. (1994). *A History of Architectural Theory: From Vitruvius to the Present*. New Jersey: Princeton University Press.

Li, L., & Shi, Y. (2021). A Preliminary Study on the Visual Properties and Material Practices of the Color Surfaces of Heritage Buildings - Take the Traditional Mineral Pigment " Shiqing" (Azurite) as an Example. *Palace Museum Journal.* (04), 65-94+110-111.

Lin, H. (1999). *The Collected Works of Lin Huiyin: Architecture Volume*. Tianjin: Baihua Literature and Art Publishing House.

Su, B. (1957). *Baisha Song Tomb*. Beijing: Cultural Relics Press.

Sun, D. (2006). *Polychrome Decoration of Ancient China*. Beijing: China Building Materials Industry Press.