DOCTORAL DISSERTATION

A Study on the Integration of Chinese Traditional Cultural Pattern Elements in Digital Design Teaching

March 2022

Xu Chong

Graduate School of Environmental Engineering
Dewancker Bart Lab
The University of Kitakyushu, Japan

Preface

This study was conducted at the Department of Architecture at the University of Kitakyushu. This research relies on the Natural Science Foundation of Shandong Province project (ZR2018PEE023), "Research on the Generation Techniques of Scroll Grass Patterns in Non-standard Buildings". This research is studying the historical development and composition of the scroll grass pattern, focusing on how to generate new decorations for non-standard buildings.

Abstract

Today, with the accelerated development of science and technology, new visual styles are constantly emerging under the impetus of science and technology. Take digitization as the technical foundation; take multimedia technology as the performance platform; change the design perspective from creativity, tools, materials, and communication methods. The digital design form not only reflects the influence of technology on art but also expresses the rational thinking of human intelligence on aesthetics. Modern design is not only a process of creating beauty, but also a strategy and a way of thinking. It emphasizes systematicity and rationality at the level of thinking and has a natural connection with logic. Therefore, a design form based on modern technology becomes a distinctive feature of modern design.

Cultural dissemination and artistic heritage represent a highly concentrated database of information in the past, which depends not only on the expansion of emerging digital media but also on the transformation of language and knowledge. Digital design with traditional patterns as elements is a continuous process from creative generation, material selection, and model establishment. This creative process is a circular process and not a non-linear process. There are sometimes differences between each step. Mutual integration and penetration occur in specific practices.

The whole process is to extract some single elements from the traditional Chinese cultural model and redesign them, and then combine them into the architectural design, trying to balance the coherence, heterogeneity of space and the uniqueness of the project. It provides favorable conditions for the reactivation of traditional models in the new era. The whole process is done based on the digital design course. The author conducts research from three aspects: theoretical knowledge, course operation exercises and after-school questionnaires, which is a process of integrating technology and art. The purpose of this course is not to discover new theories or new technologies, but to provide morphological possibilities for cultural symbols under existing digital technologies. The purpose is to try to construct new ideas and innovative digital technologies for traditional Chinese patterns, to find Possible paths for the inheritance of new traditional culture. A collision of culture and technology is achieved through experimental trials of completed buildings in otherwise unimaginable forms. It is not only a study and reproduction of traditional models, but also brings new vitality and new ideas to architectural design.

Content

List of Figures

List of Tables

Chapter 1 Research background and purpose of this study

1.1 Introduction

This chapter intends to construct the initial background for the research project and form the first delineation of thematic and instrumental approaches. As a starting point, a research background is described and analyzed, revealing the current situation of pattern, digital design, and beauty matter. By revealing the condition, the research objective of identifying a new ideal design approach that combines digital software and traditional culture is proposed and intended to be analyzed and answered. Through defining the research question inro three aspects of theory development, practice experiment, and pedagogical dissemination. the framework of this research is drawn out.

1.2 Research background

In the Chinese literary theory masterpiece " The Literary Mind and the Carving of Dragons " there is such a sentence "望今制奇参古定法",which means the contemporary innovation can be brilliant only by referring to the methods summarized by the ancients[1]. British modern cultural anthropologist Taylor made the following interpretation of "culture": "that complex whole which includes knowledge, belief, art, law, morals, custom, and any other capabilities and habits acquired by man as a member of society."[2]. Design as art belongs to the field of culture. It is "a form of spiritual and value creation that exists as a spirit, guided by a certain concept"(Figure 1-1).

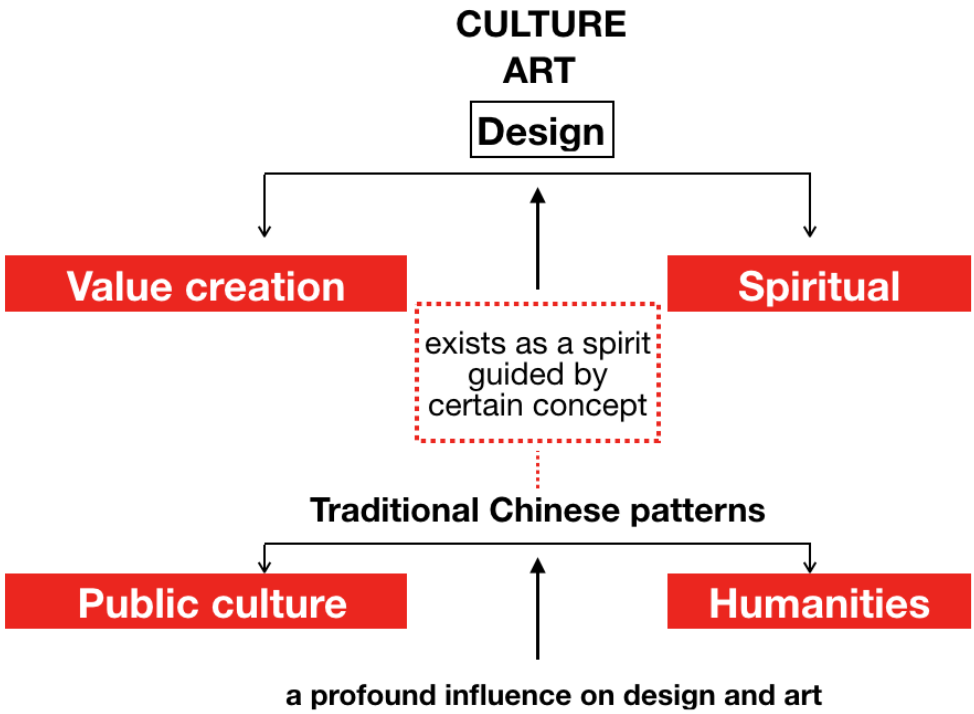


Figure 1-1 The relationship between design and tradition pattern

Traditional patterns play an essential role in public culture and humanities, and they affect people's lives in sensory vision. Their formation and development run through the whole of Chinese history, which has a profound influence on design and art. The appearance of cognitive psychology and aesthetic view of people in a specific era manifested in cultural heritage such as the historical relics and the instrument shapes attached to them. Modern

people are inevitably affected by it. With the significant enrichment of technical and material conditions, the inner nature of people's individualization has been formed, and people's demand for architectural design is also promoted. Modern design abroad and even modern art have reached the current level based on tradition. They are constantly digging and innovating their localized design language. International design companies are also looking for localized design languages for products around the world to suit the cognitive psychology of local users [3, 4]. Against this background of globalization, with the influx of foreign cultures and powerful cultures, China's modern design needs to be built based on traditional Chinese culture to create its path (Figure 1-2).

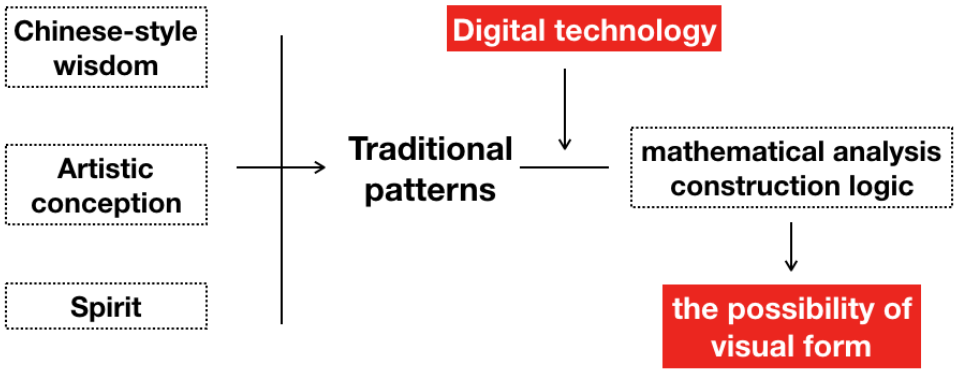


Figure 1-2 The possibility of traditional patterns

The history of Chinese patterns is very long. If we count from the period of the painted pottery culture using patterns as ornaments, it has been six or seven thousand years old, forming a continuous and magnificent pattern art. From the perspective of this extended pattern development process, it has gradual, staged, closed and other qualities. While constantly being influenced by foreign cultures, it is also continually integrating foreign elements. Under the background of regional and cultural characteristics, China's unique pattern aesthetics are formed. Its evolution process is the occurrence, development, widening and deepening of people's production, life and social civilization. Under the gradual improvement of technology and material, human society can develop from a lower level to a higher level, and the living standard is improved from simple to rich. The expression of the pattern becomes more prosperous and fuller while constantly improving and enriching; the fruits accumulated in history are rooted in the national soil, becoming an inexhaustible source of design work.

1.2.1 About Pattern

The pattern as an artistic concept appeared late, but as one of the art forms, the pattern body has existed since human society and culture emerged. Pattern as a decorative art is one of the expression forms of the origin of art. In the budding period of human civilization, in the caves of the Aquitaine, its tendency began to appear. The patterns were widely used on primitive bone carvings, tooth carvings, and later on pots and vessels. With the development and gradual maturity of practices, although some patterns have become familiar to people because of their representations and religious meanings, the continuation of their forms and aesthetic laws still ensures that the patterns become themselves rather than words or pure symbols. The Gospels of Kells in the Middle Ages, the painters, architects, and practitioners in the gold and silver industry during the Renaissance period, as well as the lines full of vitality during the Rococo period, all show that patterns were infiltrated in people's daily lives in human history in many aspects.

As different language systems, the Chinese and Indo-European language families (including English and German) show inevitable differences in terms of words. This difference has a direct impact on pattern research. In different Chinese and Western works, there are different words used to express the part about patterns. Therefore, it is very necessary to conduct etymological research to clarify the meaning of the words. Riegl used "Ornamentik" in his work[5], which is translated as decoration, but in Lukacs' work[6], "Ornamentik" is understood as patterns. Although the two are different languages, they are homologous in terms of roots. The ornament in Wilhelm Worringer's "Abstraction and Empathy"[7] and the Decorative Art in Gombrich's "The Sense of Order"[8] are both understood as decoration. But in terms of the specific content and examples discussed in these works, their research's main objects are directed to or at least contain patterns. Therefore, two questions need to be clarified. One is the category and relationship of decoration and design in Chinese, and the other is the difference between ornament and decoration in the Western language family.

"Pattern" belongs to the field of decorative arts. It does not clearly distinguish the concepts and categories of decorative art and pattern and the difference between them. Since the 20th century, Chinese scholars have begun to explore decorative arts under the influence of Western literary theories. In the early twentieth century, Chinese ethnology researcher and educator Mr. Cai Yuanpei explained the category of decorative art in a broad sense: "Decoration is the most common art."[9], which is divided into five categories according to its carrier； In the middle of the twentieth century, Mr. Pang Xunqin put forward

when discussing decoration: "In Chinese, the pattern has two meanings, one is hiding, and the other one means to add some literary grace,"[10].But this concept is no longer perfect suitable for today； According to the explanation in the Encyclopedia of China "Decorative art is a painting or sculpture attached to a certain subject. Sculptures and paintings in decorative style are independent art with free content and self-contained subjects. Its content focuses on appreciation. ...The art of decorative style, in a broad sense, has certain decorative factors. For example, murals play the main role in decorating buildings, but they no longer belong to the narrow sense of decorative art. "[11]. There is a certain paradox between the narrow decorative style and the artistic definition of decorative style. Professor Ni Jianlin explained in the "primitive of decoration art research": "For practicality or spiritual needs, the art forms used by humans on practical objects, the environment, and the human body are all of the nature of the decoration."[12] The decorative art here is the counterpart to the art that is not restricted by the carrier. Because of the practical function and carrier limitation, decorative art cannot achieve its independence. In terms of the current situation of decorative art in people's daily lives, the concept of decoration has been broadened.

Patterns are regarded as a kind of decorative art that belongs to the arts and crafts category. According to the "Chinese Art Encyclopedia Dictionary": "Patterns are the general term for decorative graphics on objects, including individual patterns, border patterns, continuous patterns, etc."[13] But in fact, patterns are also faced with unclear categories and boundaries. The study of patterns is not only in the discussion between decorative art and pure art. With the arrival of "the era of graphic culture", the pattern is the object in graphics, iconography, and semiotics due to its reproducibility. The symbolic characteristics of form and motif have become the essential element of appreciation for patterns. The nature of its order and logic is rarely discussed. Like decoration, the understanding of the concept of patterns "is not fixed. In different eras, new content is often added, and new meanings are given."[14] Nevertheless, understanding patterns from ancient documents is still helpful to understand the concept of patterns (Figure 1-3).

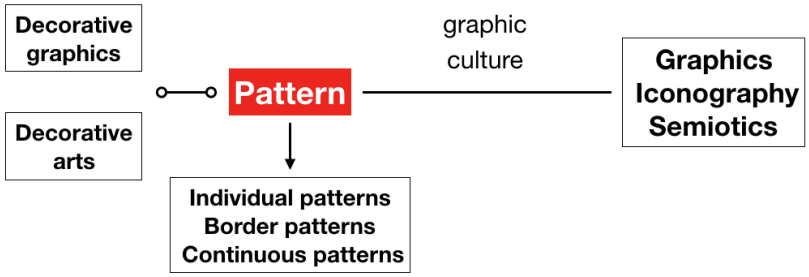


Figure 1-3 The meaning of pattern

There is a big difference between the Chinese language family and the Indo-European language family. Many Western works translate "Ornament" and "Decoration" as decorations in translating them into Chinese, but in their specific explanations, the particular objects are patterns. In 2002, Chen Ping translated Riegl's "Geschichte der ornamentik" as "basics of pattern history" in his article and developed an exposition based on this[15], while Shao Hong translated it as "the basis of decoration history," which shows that the concept of decoration and patterns is controversial. Therefore, the ideas of these two words need to be distinguished from further explaining the category of patterns. In "The Source of Decoration," Mr. Ni Jianlin discussed the difference between the two. He believes that "the decoration in English also has a broad and a narrow sense, namely decoration and ornament, patterns."[16] Chen Ping also distinguished the meanings of "pattern" from "Ornament" and "Decoration." He believes that patterns in Chinese do not entirely correspond to ornaments. He did not give more to the concept of "patterns" in Chinese. Instead of focusing on the difference between ornament and decoration, he believes that "Ornament includes decoration and beautification in a broad sense and patterns in a narrow sense[17]. In English, "Pattern" is generally translated. It is 'a perceptual structure' or 'a decorative or artistic work,' including the manual's traditional and design patterns. The decoration is a general technical term. The ornament focuses on the artistic effect of the surface, which contains the meaning of beautifying, decorating, and adding brilliance. It has nothing to do with the structure and function of the utensil; In different contexts, ornament can be interchanged with the pattern, referring to the specific decorative patterns on the exterior of the artifact.

Ornament is derived from the French "ornament" and the Latin "ōrnāmentum"[18]. In English, it means "a useful accessory that can give things elegance or beauty"[19], or "something that makes things look more attractive, but usually has no practical use"[20]. According to the "Online Etymology Dictionary," "ōrnāmentum" is derived from the verb "ōrnāre," and "ōrnāre" is derived from "ordo." Ordo means "line, level, series, arrangement." In the 14th century, in the process of being translated into English, it referred to things added as decorations to add beauty to something that belongs to itself[18]. But according to Shriver's research, the Ornament contains a sense of order related to the row-level sequence. Therefore, according to its etymology, Ornament is a decoration having a specific order law[21].

In the 7th century AD, in "Isidore," "the Greeks compared the word 'cosmos' to the Latin' Ornament,' Ornament presents the visual attributes of physical activity, which is a cycle between the external macro world and the micro world inside the body."[22] The decoration

is associated with etiquette. Ancient Greece's interpretation of linking "universe" with "Ornament" lasted until the Renaissance when Alberti first proposed Ornament as decoration and connected it with beauty. The beauty of decoration lies in its proportion and harmony[23]. Alberti explained the ornament as architectural decoration: "In the entire architectural art, the column is undoubtedly the main decoration."[24] Therefore, in English, the Ornament contains the three-dimensional space concept from the beginning. It will be directed to decorative art in architecture and extended to decoration in more carriers in subsequent applications. In addition, the understanding of the beauty implied by the decoration extended by Alberti continues to this day.

For some time after the Renaissance, the undifferentiated use of Decoration and Ornament has blurred the boundaries of meaning. This situation lasted until the 19th century when decorative arts were widely valued by the arts and crafts movement. Western art theory studies began to distinguish between the two, such as Ornament as Distinct from Decoration, The Distinction of Ornament and Decoration in Architecture, A Critical Distinction between Decoration and Ornament, etc. Although there are also unclear boundaries, more attention is paid to the difference between ornament and decoration in architecture in English. And this discussion is still going on, but the research results introduced above show that ornament is more in line with the "pattern" discussed in this topic. When looking back at history, we can make a bold conjecture. In the mid-19th century, Western researchers established their initial understanding of patterns in the art theory of three-dimensional spaces such as architecture; in China, people develop patterns in the art of two-dimensional areas such as textiles. After the end of the 19th century, the understanding of patterns developed by these two different paths began to collide and change. Soon a more integrated view of patterns, including two-dimensional and three-dimensional forms, formed. Although this expression is not rigorous, it can explain why the horizon of patterns in our country has expanded under the influence of Western art theories.

Steve Shriver mentioned in his articles: "Ornament has a sorting function and is connected with the sacred order of the universe."[21]; Daniel Pontius believes that "a thing called an ornament is a unit (decorative unit), which can also be called a 'motif.' This motif can be as simple as a square or as complex as a flower. People usually look for these themes in precedents, just as contemporary designers look through Irving Jones' "Syntax of Decoration" to find the motif."[25]. This is the same pattern motif with continuity that has been widely discussed in recent years in the traditional Chinese pattern concept.

In ancient written Chinese, "pattern" was initially recognized as two independent interpretations. One is the content on the carrier, and the other one is the carrier itself，like clothes, satins, scarves，, etc. It is the materialized entity as an idea or emotion, and it is also the place of noumenon and life. The origin of the written Chinese character "pattern" needs to be traced back as the expression of "content" and also follows the generation of the concept of "text." The interpretation of "pattern" in the "Jade Chapters" Chinese dictionary edited by Gu Yewang during the Liang dynasty is "the texture on silk."[26, 27]. There are seven occurrences of "patternin" in the "Erya" [28]. Only one time refers to the ideography. Others in the articles can be interpreted as the phenomenon of "pattern" in nature, that is, the texture of animals and plants; At the same time, the oracle bone inscriptions are a kind of hieroglyphs, and the writing of the characters likes a crisscross texture. "Pattern" in Chinese also can be interpreted as the crisscross texture or image embroidered on silk, just as the "Kangxi Dictionary·Pianhai" explained that "every brocade embroidered text is called a pattern." [29]

Another meaning of "pattern" in Chinese refers to the imitation of an existing existence. In Jiyun, a Chinese rime dictionary published in 1037 during the Song Dynasty, noted: "Pattern" can be extended to sample law, paradigm, which itself has the inherent provisions of statutes or conventions[30]. In Shuowen Jiezi of the Qing Dynasty, it is further clarified that the imitation of "pattern" results from the human subjective initiative. It also metaphors an indeed established paradigm[31]. To expand the concept of patterns, from only referring to the weave pattern of textiles to the category of injecting identification symbols, it can then represent a high aesthetic value by itself. Patterns are decorations on a two-dimensional plane, such as textiles based on existing motifs or patterns for aesthetic or identification purposes. In the context of ancient Chinese, although patterns are used less frequently, the conceptual orientation is still evident. Its essence can be summarized as "functional basis, symbolic meaning and aesthetic value in three aspects."[32]. With the influence of Western academic thoughts in modern times, the category of patterns has once again been broadened. In 1934, in Lin Huiyin's "Pre-examination of Jinfen Ancient Architecture," she used "pattern "when describing the decoration of the pillar on the stone bridge. "The patterns of the column version are different, such as lotus, Ruyi, bell, drum, etc."[33]. Here the pattern no longer refers to the two-dimensional decoration on the plane; it also points to the three-dimensional design. Since then, a large number of sculptural patterns in architecture and utensils have appeared in academic research.

1.2.2 About Digital developments

Chinese traditional patterns mainly refer to symbolic meanings created in the birth and development process of Chinese civilization. They represent the aesthetic taste and value orientation of every period. It is inevitable to brand with the mark of era culture. In the early time, the traditional patterns originated from nature. The beauty of them came from their natural form. After continuous simplification, the models became refined and represented a very close relationship between geometry and mathematics. "Harmony of the form consists in the proper balancing and contrast of the straight, the inclined, and the curved." [34]. "All junctions of curved lines with curved, or of curved lines with straight, should be tangential with each other." [34]. For the Chinese patterns, triangulation is the main feature. The geometrical arrangement is absolute and undisguised but softened by free treatment of the intermediate spaces left by the triangulation [35]. Of course, the patterns are the symbol of images of languages, the pictorial expression of words. Thus, they have a close relationship with the written words. It is an essential branch of the language symbol system. The Chinese character symbol system simulates the object of nature and can also engrave the continuity of cultural communication.

Traditional patterns play an essential role in the conventional design. First, it provides abundant resources for design. In the long history of patterns, its symbolic and artistic conception becomes a unique form. The original study of pattern logic does not originate from the design but the kaleidoscope. Scottish scientist and inventor David Brewster were one of the early scholars in this area. The research on the mathematical logic behind the pattern graphics appeared in the kaleidoscope. David revealed the different levels hidden in the pattern with simple line drawing, brought some elementary concepts of geometry into play to create an attractive context [36]. A deep mathematical foundation also supported the patterns created by Islamic craftsmen in the workshop. More than a hundred designs, all based on a simple schema, are presented in "The Power of Form Applied to Geometric Tracery" [37]. George Bain described how mathematical analysis could be used to reorganize and understand Celtic knots as essential representatives of traditional British culture. The fabricated structure was based on a three-grid system [38]. Fractal mathematics also has a significant impact on the remodeling of patterns [39]. In terms of construction, vegetal motifs, and geometric patterns were gradually applied in Islamic art and architecture under the influence of ancient culture [40]. Geometry patterns based on mathematical division became the most prominent decorative system. They were linking woven designs to a mesh system [41]. It played an important role in the structural and decorative elements of traditional

Persian architectures [42]. The author tried to solve 3D problems through 2D patterns. The solution was to generate new intricate patterns by using simple existing components or modules, refining, and defining criteria for Muqarnas classification. Many famous architects expressed their opinion on ornaments and patterns in the twentieth century, like Adolf Loos's famed theory "ornament and crime", whose real meaning is imagining an aesthetic liberated from ornament. He did not lose his faith in ornament but hoped to make and use new patterns and new decorations [43]. Under "digital technology", the traditional model has more possibilities and openness. Professor Picon proposed that architects should refocus on the surface and facade because of the rediscovery of the patterns and digital technology development [44]. He also defined the contemporary trend, pointing out that "the reinvention of ornament" is better than "the return of ornament" [45]. The key to development is the historical analysis. Rather than "bringing back", there is no pure utilization of past things [46]. Therefore, in the digital age, the application of ornament in contemporary architecture is grounded on the masterly use of computer-aided design and manufacturing programs. In this sense, ornament today has become creative, rather than the retrospective element in which architects reinterpret, design, and fabricate their own volition [47]. The research on the traditional pattern in China was initially from Lin Huiyin, who discussed the influence of Indian Buddhist art in the Western Regions and the exchanges and collisions between China and the Western countries in terms of architecture, sculpture, and patterns in 1933 [48]. Linxun analyzed the two-dimensional pattern field in-depth, systematically summarized the periodic patterns and quasi-periodic patterns, and proposed detailed two-dimensional illustrations [49]. Due to the limitations of technology, aesthetic and artistic aspects of traditional Chinese patterns are only presented by the two-dimensional spatial showing, such as form and color, with merely making up and piling up, little innovation. It is not the natural inheritance and reuse of traditional patterns.

In combining pattern graphics and digital technology, designers are studying the "free interface" of digital technology, looking forward to continuous innovation and leading fashion. From digital printing and fine carving technology to 3D printing, light-sensitive patterns, and more, traditional models exist in different forms of innovative thinking. Designers try to deepen their thinking and convey the spirit and connotation of conventional designs with different visual aesthetics. The digitization of the pattern makes the projects achieve extraordinary degrees of freedom. The system's automatic generation model and designer's recreation mode have substantial autonomy. Digital patterns can be derived from 2D to 3D and even 4D, according to different pieces of computer software, such as holographic stereo imaging technology and virtual reality technology. Shanghai Pioneer

Design Co. Ltd. XUBERANCE has opened up a brand-new aesthetic design method to interpret and revive traditional Chinese culture. They try to reinterpret it with new technology. The project: "Viewing the Clouds", inspired by Liu Yuxi's masterpiece (a Chinese poet, philosopher, and essayist, 772~842) and named the entire series of works with the expression of clouds. The Chinese classical garden decoration patterns present a different modern aesthetic concept through 3D printing technology [50].Zaha Hadid Architects introduced a new experimental architecture during the annual Milan Design Week as part of the City Show in 2017. The project is called "Thallus" [51], which means that the stems and leaves of the plant are not distinguished in Greek. It is an experimental structure investigating form and pattern generated by advanced manufacturing and computational methods.

Designer Benjamin Dillenburger and Michael Hansmeyer used the algorithmic design method and 3D printers to complete an extremely complex object: The Arabesque wall. It is a massive, printed wall with ornamental details at the scale of millimeters. It plays with the aniconic, geometric tradition of arabesque ornaments by creating intricate constellations that are at once figurative and abstract. The Arabesque Wall's rhythmic, interwoven curve elicit viewers' individual interpretations and engage viewers to approach it, touch it and to explore. Each perspective offers new impressions. Just as with arabesque ornaments, the compositional principles of the Arabesque Wall are both geometric and mathematical. They are based on an iterative tiling and division of surfaces. An algorithm folds a single surface over and over again until a structure composed of millions of microscopic facets emerges. Shifting the design process to this abstract level has a dramatic impact, creating a complexity and richness of detail that would otherwise be almost impossible for a designer to specify or conceive of. In uniquely employing 3D printing for its fabrication, the Arabesque Wall heralds a highly differentiated and spatially complex architecture in which ornament and formal expression cease to be a luxury. Using computational design and digital fabrication, even the most lavish and one-of-a-kind architecture can now be materialized with relative ease. The Arabesque Wall thus escapes the paradigms of rationalization and standardization and celebrates architecture as a precious cultural component of our environment. Its complexity is a new challenge for people's perception ability. The designers explained: Architecture should be surprising, exciting, and irritating. The work presents a porous, multi-layered texture with a seemingly endless mysterious beauty, from simple to complex. It shows how the ability of geometric space expression under digital technology makes beautiful architecture from conception to reality. It abandons the traditional paradigm of rationalization and standardization. The new architectural concept emphasizes the viewer's

understanding and perception, inspiring the viewer's sense of joy, curiosity, and confusion [51].

Numerous studies have shown that it is incomparable between pattern art and many other art forms in terms of the long history and scope. Its existence provides a rich source of value for design. With the emergence and penetration of new materials, new processes, and new technologies in different periods, new developments in design will re-innovate based on traditional forms and meanings. Education is of utmost importance for the future of sustainable development, especially in the field of architecture. It is a key factor in the reorientation of the design industry towards a system of buildings and cities [52]. As one of the most complicated negotiation processes and globally recognized cultural practices, architectural design is both an academic topic and a career direction. The design should be comprehensive, including all technology and aesthetics and all technical, aesthetic, political, and economic issues in a particular society.

1.2.3 About Form Beauty

What is Beauty? Beauty is, for the more significant part, some quality in bodies acting mechanically upon the human mind by the intervention of the senses[53]. whether it comes from the sensory effects of pleasure or sadness, spiritual or recognizable, is the specific part of the emotional brain[54-56]. The mathematician Ron Aharoni claims that mathematicians share with poets a desire to engage with Beauty, which leads them to new knowledge[57]. Lisa Samuels, Professor of English and Drama at Auckland University, has explained: ''Beauty [in poetry] is a non-conceptual way of knowing. We have developed, implicitly, a sense of the non-conceptual in artistic Beauty… in fact … what beauty "knows": that knowledge is also – perhaps most importantly – what we do not yet know.'[58]. So, Beauty is a highly subjective experience. An external observer can ever detect any uniformity in matters of taste and Beauty[59]. But throughout most of the 20th century, in the visual arts and the humanities – including architecture, politics, psychology, poetry, and music – Beauty became a denigrated phenomenon, a taboo word. Yet, the emotional experience of it has remained real, with people referring to it daily. Immanuel Kant, a writing in 1790, aesthetic judgment as "disinterestedly free'' and Beauty as ''purposefulness without purpose"[60].

Subjective beauty, in early time, vision is the crucial mechanism in acquiring knowledge of the world around us. It is the most efficient mechanism to gather knowledge infinitely. Thus, our brain reality is our only reality[61]. Beauty becomes the guide of design. 'Works of

visual art provoke a particular kind of emotion… the aesthetic emotion' and that this same kind of emotion is evoked by 'every kind of visual art' (including architecture).'All works of art [must have] some common quality'; the discovery of that 'common quality' will lead us,'[62]. Most painters and designers are also neurologists/painters work and re-work until an effect is achieved that pleases them – their brains. If in the process it pleases others, 'they have understood something general about the neural organization of the visual pathways that evoke pleasure, without knowing anything about the details of that neural organization or indeed knowing that such pathways exist at all.'[61] It is the artist's pursuit of beauty； The desire of mathematicians and poets for beauty is the longing for new knowledge[60].

Beauty in architecture also would nourish the human emotional brain. The appreciation of beauty, no matter where found, is hardwired into our brains. When architects are asked to describe beauty in architecture, most refer to the Renaissance ideal of perfection, some to an elegant line or a neat detail, without reference to beauty's much more profound and enigmatic qualities. There are some common guiding elements in architectural aesthetics, and these universal perceptions make architects believe that their beauty is recognized. What universality architectural beauty may possess probably lies in satisfying inherited brain concepts of proportion, harmony, and geometric relationships that are more formally expressed in mathematical terms in the domain of architecture. The mathematical relationship is used as a partial key of the "beauty" relationship, symmetry, balance, and precise relationship. The sculptor Kanon's work "Doryphoros" its beauty comes from a strict mathematical sequence. Beauty is not entirely as subjective as it may at first seem[59].

Architecture could be art: a temporary cultural register from which buildings such as Frank Gehry's Bilbao Guggenheim Museum (1997) emerged. Architecture's aspiration to beauty was pre-eminent for thousands of years, triumphantly leading the visual arts until the 1920s, when Early Modernism generated a significant new aesthetic[63]. Architects' troubled relationship with "beauty" began in the 1940s[64]. Mies raised architectural beauty: 'objective limits' and 'no subjective license'[65]. German philosopher Alexander Gottlieb Baumgartenren argues that aesthetics is an ongoing act of subjectivity[66]. By 2006, visual art started to humanize digital technologies due to creative encounters between art, science, technology, and human consciousness. The brilliant architects know how to probe the human mind with design techniques that are unique and known to them, as they intuitively understand the visual pathways that evoke pleasure. The beauty of the design should accept the validity of human judgment as part of its process and the role of intuition and insight. Some architects believe that buildings that pay more attention to appearance are naive or

innocent. This is perhaps attributable to a cultural bias that over-intellectualizes the design process, undermining visual thinking as the leading generative force in the architectural design process[67].

Whatever other demands go into an architectural design; beauty must be a central element. The beauty experience stems from the visual conception, its source in the contemplation of the natural world, and a heavy dose of natural beauty. Its expertise adds to the health of its individuals and thus to society's wellbeing. It is not a luxury but an essential ingredient in nourishing the emotional brain. New techniques and digital technologies led to executed beauty. London's ecologic Studio tries to incorporate living micro-organisms within architecture and uses new methods to read their evolving appearance to measure environmental value. Bio-digital aesthetics will be a value system of post-Anthropocene architecture. Tech Hut pavilion at Expo 2017 in Astana, ecologic Studio installed a photosynthetic sculpture, hosting living cultures of cyanobacteria, that would symbiotically breathe with the visitors of the Hut. The firm's partners Claudia Pasquero and Marco Poletto combined this approach with digital technology to create striking organic and inorganic assimilation that celebrates the beauty of non-human intelligence[68, 69]. Internal view of the photosynthetic sculpture， as visitors exhaled carbon dioxide, they could manually pump it into the sculpture, feeding the living cultures and releasing fresh oxygen. The coral-inspired morphology with its convolutedness increases the irradiated surface and the lengths of molecular exchange. Architect and educator Marjan Colletti considered Beauty in the 'Fourth Industrial Revolution' – the post-digital age [70].

He begins with an ode to Beauty and continues in an autobiographical mode, blending fact and personal experience. At points, he evokes chimeras, myths, and the South Tyrolean landscape; at others, he describes aesthetic arousal in art and architecture and its power to scare – all in search of personal Beauty. The design borrows from and reinterprets some classical ornaments and embellishments in Baroque music, such as the appoggiatura [from the Italian appoggiare, to lean upon], the acciaccatura [from Italian acciaccare, to crush], the glissando, Schleifer, trill, mordent and turn. Alisa Andrasek's work is a restless search for the beauty of novel architectural forms and techniques utilizing autonomous agents, architectonic algorithms, machine learning, and robotics. This research used stigmergy behaviour, another example of agency-based systems, which could be programmed to be highly adaptive to local data. What is most intriguing and attractive in this case, is contrasting organic aesthetics emerging from algorithms like stigmergy, with its plant like formations, and the hyper-rationalisation and genericity of voxelised geometry. Different resolutions were

introduced in the facade panels, by using an octree algorithm. The result is a building skin that from afar looks like a plant, but in close up has almost Minecraft-like aesthetics coming from a multi-resolution voxel field. Organic stigmergy (stígma + ergon) partly plays a role in the distribution of data through the facade field, rather than generating geometry. It leaves its imprint in the density of geometry[71, 72]. The beauty and strangeness of the project come from the intricacy and unusually high resolution of articulation. There is a contrast of organic aesthetics emerging from algorithms like stigmergy with plant-like formations. It also reflects the hyper-rationalization and discreteness of voxelized Geometry.

The glimpse of architecture beauty discussed here is in many ways optimistically driven towards an almost future discipline, suspended between two poles. One part in an opportunistically absorbing convergence of exponential technologies and percolating novel design intuitions from science; the other being the search for awe and wonder, for aesthetic expressions in design that are strange and stunning, previously unseen. The two are not opposed, but rather in a secret relationship, with science and an evolving plethora of technologies, as a rich source to uncover novel aesthetics, revealing and materializing forces that are usually hidden and go beyond existing imagination.

1.3 Purpose of this study

1.3.1 Research motivation

Why can so many excellent pattern graphics be passed down for thousands of years? Because of their form and the Chinese-style wisdom, artistic conception, and spirit embodied in them. They are not only decorative figures but also spiritual symbols. Their expression is subtle and distant. But nowadays, traditional patterns are mostly used on a two-dimensional level. Most of them use form, connotation, and color, or even simply display. The development of patterns has always stayed in a single subject. In the current situation of interdisciplinary development, it has not been paid attention to by many people; and the inheritance and development of traditional culture should start with students or young people. They need to be noticed before they can be protected; try to use them and then talk about inheritance.

Under the digital period, mathematical analysis and construction logic are used in the graphic design of the pattern. It should strengthen the possibility of visual form. Geometric form under the parameter control to form various visual effects with limited modules, which can generate some unpredictable geometry during the deliberate trial process. It will provide favorable conditions in the new era for the traditional patterns to be re-activated. It is a combination of technology and art.

For architecture design, in addition to carrying the meaning of the architecture's functionality, it also has the meaning of the non-building itself, like culture, technology, and history. Among them, culture can be understood as communication, then one of the fields in which it will undoubtedly find itself most challenged is that of architecture (eco semiotics and architecture). Build new ideas and innovative digital expressions for traditional Chinese patterns, realize the collision of culture and technology from experimental trials on the existing architectures in other unimagined forms. It is the research reproduction of traditional patterns and brings new vitality and fresh ideas for architecture design. Besides the practical and technical problems, architectural design is a combination of technology and humanity and culture, how to integrate this culture into architectural design. This would be identified as the theoretical problems we are facing in this study.

1.3.2 Research Objective

As a consequence of the aforementioned initial problems, the objective of the research project is twofold. The thesis attempts to contribute to digital design and its orientation towards culture development and a multi-disciplinary cross sustainable approach.

On a theoretical level, the objective is to identify and formulate a methodological framework for such an approach. The intended framework is based upon a series of prescriptive propositions, rather than taking the form of a guide or design principles. This has the intent of creating an open and expectantly adaptive path for both an approach to the existing digital architecture orientation and a contribution to what is considered a cultural heritage orientation. This is a response to the current tendencies about the combination of tradition and modernity. On an applied level, the objective is to provide morphological possibilities under the existing digital technique in cultural symbols.

Objective: Explore the possibility of traditional patterns based on digital design and support the inheritance of traditional culture.

The ultimate objective of this project is to enhance the ability of the practitioners to create tectonic architecture. Within the limits of the study, the objective of this research project is to enhance the understanding of traditional graphic logic. It is not to reveal all the possible ways of combining all graphics and technologies, but the purpose is to understand the characteristics of the composition. This understanding should be combined with the current emerging technologies and at the same time reveal what makes and hinders the possibility of reusing traditional things. The focus here also includes design tools, the design practice intentions and processes deviate towards the extreme conditions' informal exploration, sustainability aesthetics, generative typologies, and geometrical, sometimes surrealistic, illusions. Finally, when the goal of generation (through the development of design tools) is to allow more people to pay attention to the culture, the knowledge generated should also be used for the inheritance of traditional culture.

1.3.3 Scientific originality of the study

History is an echo of the past in the future, a reflex from the future on the past. Human beings are living in this era, surrounded by wireless communication and digital information. It is an innovating time of recognizing space, time, and material. Technology has changed the original mode of culture, society, and all aspects of life, even the relationship between

people because of the intervention of "digital". The combination of digital technology and architectural design has achieved the leap progress of the design from the original computer-assisted drawing to the computer-assisted designing. Design forms the thinking mode of multidisciplinary integration. Digital technology, as a new solution and a new tool in global architecture, is attempting to inject new vitality into the classical elements.

The thesis' greatest scientific originality lies in the combination of tradition and modernity, culture and technology by "sculpturism". The word "sculpturism" first appeared in the evaluation of Frederick Kiesler's project "The Endless House". It was the synonym of Beaux-Arts schools of design and aimed to rethink and redefine the technology in combination with feeling, material, and structure[73, 74]. Lars Spuybroek wanted to stay far away from sculpturism [75, 76] because it means "favors form over function" and seeks to adhere to the aesthetic values of other works and disciplines[77] In some publications, editors use the word "sculpturism" to describe the influential architecture, including the projects by LA legends Eric Owen Moss, Thom Mayne, and a host of emerging talents[78]. In the early times, architect Frank Gehry developed a very highly specific visual language that determines all his projects. His success was remarkable. People began to realize the potential of digital software[79]. In the 20th century, Lebbeus Woods was classified as a different kind of architect by the mainstream architecture circles at that time, because of his extremely unconventional heterotopia creativity and astonishing architectural form like high-houses[80]. In the 21st century, Zaha Hadid created a personalized architectural language with advanced digital design tools. Her projects became the most sculptural and beautiful[81]. In recent years, Professor Hernan Diaz Alonso (an Argentine-American architect, professor in SCI-Arc in Los Angeles) pushed the "sculpturism" to an extreme degree[82, 83]. He commented on the cases in his book: They are grotesque, not ugly. They are mannered, not baroque. They are the products of an excellent eye. They are projects that look a whole lot less like conventional architecture. They seem to have undergone an amazing process of mutation that has made them big and hard[84]. The idea of "digital sculpturism" we talk about allows the designers to focus on the artistic and expressive possibilities of arts and architecture. The richness details of unique and potent elements are the reflection of "excitement, enthusiasm, energy and high spirits"[85]. In this aesthetic way, precise visual effects become the primary consideration. The design principles and methods presented by "digital sculpturism" emphasize the sculptural expressiveness in object forms. The form provides the conditions for the seamless connection between reality and virality, and less attention to functions, which is conducive to the poetic expression of modeling. Many iterations models were written by digital software, with the complex system attached to the

original structure, which was eventually applied to architectural design. The new digital technology can not only strengthen the impact of visual architectural form but also can make the design more ethnic, aesthetic sense, more stylish.

On the other hand, in the long-term circulation of traditional Chinese patterns, its artistic conception has formed a unique ethnic form. Like glaze, raindrop glaze, cloud pattern, water flowers, and moon in the mirror are all manifestations of the combination of virtuality and reality. This is a mysterious beauty, but this obscure beauty is mostly unspeakable. Has art become a science with the development of technology? Can art be analyzed and researched scientifically? Will art and science become a new whole in the future? What's more, the pattern body is a kind of craft art, so when emphasizing its application function, it is even more closely related to technology. Compared with "pure art", pattern graphics have greater comprehensiveness and intersection. In design research, the duality of art and technology analysis runs through from beginning to end. Traditional pattern innovation should not be limited to the previous aesthetic scope but should be traced back to its original consideration of technology. The traditional Chinese pattern body was established under the support of powerful mathematics. Digitization and parameterization are emerging technologies now under the unified control of mathematics in many architectural and product fields. They are used to realize the coordination and suitable cooperation of multiple elements and conditions under a significant situation. Given its many similarities with the pattern framework, combining technology and graphic design brings new life to the traditional pattern and develops new ways of thinking.

1.3.4 Research flow

With the research objective, it is possible to formulate the research question that is operational as well as a number of auxiliary questions that can shed light on the various aspects of the research question.

How to complete the combination of modern technology and traditional things? Can the inheritance of patterns be completed in this process?

Auxiliary questions:

Theoretical background: The generation and development of traditional patterns?

- How are traditional pattern elements classified?
- How is the concept of tectonics in the digital era understood?
- How to understand the skeleton of the pattern?

The design practice: How to use digital software as a practical tool in the process of

generating traditional patterns?

• What enables a digital practice?

• How does the cooperation between the individual participants, operations and inspiration involved in the integration process, and the design tools used, achieve the operations?

Realization in pedagogical: How to realize the inheritance of traditional culture in the process of interaction and mutual influence?

• What degree is open thinking influence design pedagogy?

• How can the introduction of advanced technology enhance the understanding of traditional pattern graphic thinking?

Based on above research questions, and the mixed methodology strategy, the research framework of this study is planned as follow (Figure 1-4):

The first part is consisted by chapter 1 ,2 and 3, which described the research background and the purpose of the study, by introducing the pattern conditions, development of digital technologies, and the form beauty matter. Framing research question and objective, choosing research methodology, and proposing thesis hypothesis.

The second part is the analysis and interpretation of the pattern composition logic. Including individual patterns, two-direction patterns and four-direction patterns. Formed the initial idea of interpreting element patterns to the concept of digital design.

The third part is the combination of the digital practice experiments, introducing the entire pattern is extracted from the graphic to the process of redesigning through the elements. Realize the design process from complex to simple, and then from simple to complex. Several cases show how this process is realized and how to promote the innovative expression of patterns.

The fourth part is data analysis, which includes 316 requests for applicants in the industry and questionnaires survey analysis for the pedagogy, 784 students participated in the basic survey, among them 153 students who participated in the digital design course based on traditional patterns are volunteering to share their feedbacks for this pedagogical questionnaire survey. A comparison between before and after class for the understanding of the topic is analyzed, and specific analysis for different situations.

The final part is conclusions, summarized the above studies from theory, practice, and pedagogy feedback, three study paths, drawn the comprehensive image of the possibility of the combination of digital technology and traditional pattern, and the imagination of the future developments.

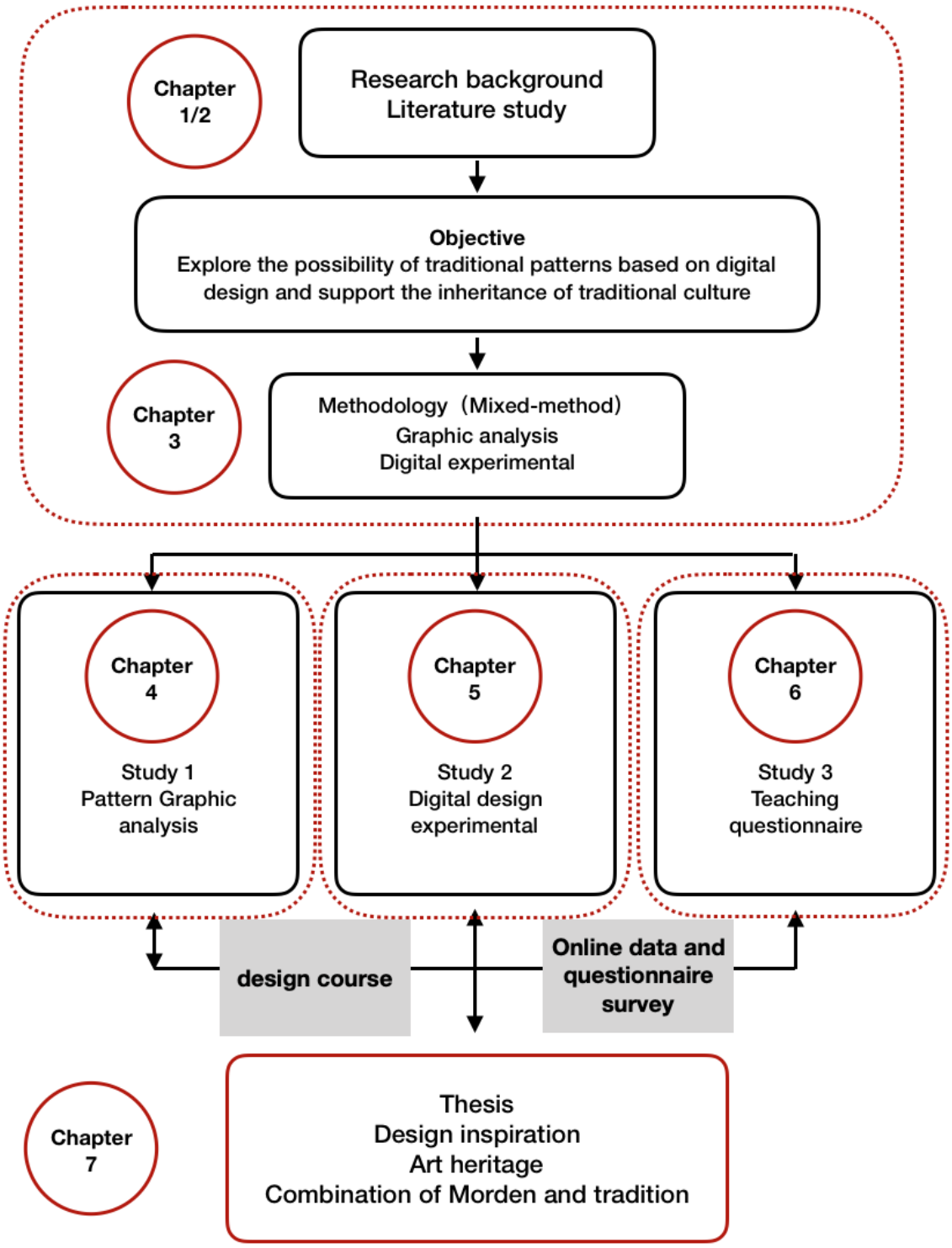


Figure 1-4 The structure of research flow

Reference

1. Shih, V.Y.-c., The literary mind and the carving of dragons. Pacific Affairs, 1959. 32(3).
2. Tylor, E.B., Primitive culture: Researches into the development of mythology, philosophy, religion, language, art, and custom, Vol. 1. 1924.
3. Norman, D.A., The Psychology of Everyday Things, New York, Basic Book. paperback as the Design of Everyday Things, 1988: p. 1990).
4. Ekman, P., Emotions revealed: recognizing faces and feelings to improve communication and emotional life. New York. NY: Times books, 2003.
5. Riegl, A., Stilfragen. 2010: Рипол Классик.
6. Lukács, G., Die Eigenart des Ästhetischen. 1963.
7. Worringer, W., Abstraction and empathy: A contribution to the psychology of style. 1997: Ivan R. Dee.
8. Perkins, D., Gombrich: The Sense of Order: A Study in the Psychology of Decorative Art. Studies in Visual Communication, 1980. 6(1): p. 77-81.
9. Yuanpei, C., Cultivation of the Chinese (Chinese Edition). 2017: Sichuan Literature & Art Publishing House.
10. Lv, P., A History of Art in 20th-century China. 2010: Charta.
11. Perkins, D., Encyclopedia of China: History and culture. 2013: Routledge.
12. Ni, J., Sources of Decoration - Research into Primitive Decorative Art. June 2007, Chongqing: Chongqing University Press.
13. Qiyong, F., Chinese Art Encyclopedia Dictionary. 2004: The Commercial Press.
14. Dao-yi, Z., Aesthetic Ideas on Art Appreciation. Journal of Nanyang Teachers College, 2002.
15. Ping, C., Riegel and Art Science. New art, 1999(1): p. 43-47.
16. Jianlin, N., The Source of Decoration. 2007, Chongqing University Press.
17. Ping, C., The Historical Reconstruction of Decorative Patterns. New Design, 2007.
18. Meggers, F., et al., Reduce CO2 from buildings with technology to zero emissions. Sustainable Cities and Society, 2012. 2(1): p. 29-36.
19. de Montarroio, T., Residential building upgrade in Montarroio. 2016.
20. de Montarroio, T., Residential building upgrade in Montarroio.
21. Shriver, S., A Short History of Ornament and Its Relationship to Narrative Painting. Kitsch and Beauty. California: Lutheran University, 2014.
22. Bloomer, K. and K. Jespersen, Ornament as Distinct from Decoration. 2002.
23. Ahani, F., I. Etessam, and S.G. Islami, The Distinction of Ornament and Decoration in Architecture. Journal of Arts and Humanities, 2017. 6(6): p. 25-34.

24. Alberti, L.B., On the art of building in ten books. 1988: Mit Press.

25. Pontius, D. Ornament vs. Decoration. 2010; Available from: http://www.danielpontius.com/ornament-vs-decoration/.

26. WANG, Y.-q. and Y.-z. CAI, Reviewing the Characteristics of Phonetic Standard in Gu Yewang's Book of Jade based on Normative Universality. Journal of Guangxi Normal University (Philosophy and Social Sciences Edition), 2014: p. 05.

27. Yang, B., The" Zhang" on Chinese Southern Frontiers: Disease Constructions, Environmental Changes, and Imperial Colonization. Bulletin of the History of Medicine, 2010: p. 163-192.

28. Coblin, W.S., Erh ya, in Early Chinese Texts: A Bibliographical Guide. 1993, University of Iowa. p. 94.

29. Yushu, Z., Kangxi Dictionary. 2016, Jilin Culture and History Press.

30. Du, D., Jiyun. 1037, Shanghai: Shanghai guji press.

31. Shen, X., Shuowen Jiezi (5 Volumes)/ The Interpretation of Chinese Classics in Shuowen Jiezi (5 Volumes)/ The Interpretation of Chinese Classics 2020, United press.

32. Xu, C., Y. Huang, and B. Dewancker, Art inheritance: an education course on traditional pattern morphological generation in architecture design based on digital Sculpturism. Sustainability, 2020. 12(9): p. 3752.

33. Sicheng, L.H.L., Pre-examination of Jinfen Ancient Architecture. China Homes, 2018. 02.

34. Jones, O., The Grammar of Ornament: 1856. 1856: Day.

35. Jones, O., The Complete Chinese Ornament: All 100 Color Plates. 2012: Courier Corporation.

36. Graf, K.-D. and B.R. Hodgson, Popularizing geometrical concepts: the case of the kaleidoscope. For the Learning of Mathematics, 1990. 10(3): p. 42-50.

37. Billings, R.W., The Power of Form Applied to Geometrical Tracery. 1851.

38. Bain, G., Celtic art: the methods of construction. 1973: Courier Corporation.

39. Mandelbrot, B.B., Fractals: form, chance, and dimension. Vol. 706. 1977: WH Freeman San Francisco.

40. Kharazmi, M. and R. Sarhangi, An analytical study of the methods of design and geometric constructions in architectural ornaments of the Friday Mosque of Forumad. Nexus Network Journal, 2016. 18(1): p. 275-310.

41. Clévenot, D. and G. Degeorge, Ornament and decoration in Islamic architecture. 2000: Thames & Hudson London.

42. Maleki, M.M. and R.F. Woodbury, Reinterpreting Rasmi Domes with geometric constraints: a Case of Goal-seeking in Parametric Systems. International Journal of

Architectural Computing, 2008. 6(4): p. 375-395.

43. Long, C., The Origins and Context of Adolf Loos's "Ornament and Crime". Journal of the Society of Architectural Historians, 2009. 68(2): p. 200-223.

44. Schnabel, M.A., Digital Culture in Architecture: An Introduction for the Design Professions. 2010, Earthscan 14a st cross street, London, Ec1n 8xa, England.

45. Picon, A., From Tectonic to Ornament: Towards a Different Materiality. Digital Culture in Architecture, 2010: p. 115-164.

46. Foucault, M., Space, knowledge and power (interview with Paul Rabinow). Rethinking architecture: A reader in cultural theory, 1997: p. 367-380.

47. Picon, A., Ornament: The politics of architecture and subjectivity. 2014: John Wiley & Sons.

48. Guixiang, W., Bulletin of the Society for Research in Chinese Architecture: Its Establishment, Development and Influence. World Architecture, 2016(1): p. 20-25.

49. Lin, X., Symmetry and Developing Ideas: Construction-based Approach to Geometry of two-dimensional Pattern Designs. Packaging Engineering 2006. 27(2): p. 157-162.

50. Rao, P., Sustainable development. Vol. 1. 1999: Blackwell Publishers.

51. D'agostino, D., P. Zangheri, and L. Castellazzi, Towards nearly zero energy buildings in Europe: A focus on retrofit in non-residential buildings. Energies, 2017. 10(1): p. 117.

52. Porras Álvarez, S., et al., A comparative study on sustainability in architectural education in Asia—With a focus on professional degree curricula. Sustainability, 2016. 8(3): p. 290.

53. Burke, E., A Philosophical Enquiry into the Origin of our Ideas of the Sublime and Beautiful. 1958: Columbia University Press.

54. Kawabata, H. and S. Zeki, Neural correlates of beauty. Journal of neurophysiology, 2004. 91(4): p. 1699-1705.

55. Ishizu, T. and S. Zeki, Toward a brain-based theory of beauty. PloS one, 2011. 6(7): p. e21852.

56. Zeki, S., et al., The experience of mathematical beauty and its neural correlates. Frontiers in human neuroscience, 2014. 8: p. 68.

57. Aharoni, R., Mathematics, poetry and beauty. Journal of Mathematics and the Arts, 2014. 8(1-2): p. 5-12.

58. Samuels, L., Introduction to Poetry and the Problem of Beauty. Modern Language Studies, 1997: p. 1-7.

59. Zeki, S., Beauty in Architecture: Not a Luxury - Only a Necessity. Architectural Design, 2019. 89(5): p. 14-19.

60. Graham, G., Philosophy of the arts: An introduction to aesthetics. 2005: Routledge.

61. Zeki, S. and J. Nash, Inner vision: An exploration of art and the brain: Oxford university press. 1999, Oxford.

62. Bell, C., Art. 1914. London: Chatto and Windus, 1924.

63. Reisner, Y., Architecture and beauty: A symbiotic relationship. 2019, Wiley Online Library.

64. Reisner-Cook, Y. and F. Watson, Architecture and beauty: conversations with architects about a troubled relationship. 2010: RMIT University.

65. Rowe, C., et al., The architecture of good intentions: towards a possible retrospect. 1994: Academy Editions London.

66. Welsch, W., Aesthetics beyond aesthetics. 2002.

67. Reisner, Y., Abstraction and Informality Generate a New Aesthetic An Interview with Kazuyo Sejima. Architectural Design, 2019. 89(5): p. 30-37.

68. Pasquero, C. and M. Poletto, Beauty as Ecological Intelligence: Bio‐digital Aesthetics as a Value System of Post‐Anthropocene Architecture. Architectural Design, 2019. 89(5): p. 58-65.

69. Pasquero, C. and M. Poletto, Bio-digital aesthetics as value system of post-Anthropocene architecture. International Journal of Architectural Computing, 2020. 18(2): p. 120-140.

70. Colletti, M., Exuberance and digital virtuosity. 2010, John Wiley & Sons, Ltd. Chichester, UK.

71. Andrasek, A., Indeterminacy & Contingency: The Seroussi Pavilion and Bloom by Alisa Andrasek. Architectural design, 2015. 85(3): p. 106-111.

72. Andrasek, A., Open synthesis//Toward a resilient fabric of architecture. Log, 2012(25): p. 45-54.

73. Spuybroek, L., The architecture of continuity: essays and conversations. 2008: V2_ publishing.

74. McGuire, L., Space within: Frederick Kiesler and the architecture of an idea. 2014.

75. Ludovica Tramontin, M., Textile Tectonics: An Interview with Lars Spueybroek. Architectural Design, 2006. 76(6): p. 52-59.

76. Spuybroek, L., The matter of ornament. 2010.

77. Galker, D., Los cinco sentidos: arquitectura y diseño. 2006: Universidad Autónoma Metropolitana Azcapotzalco.

78. Rose, J., A New Sculpturalism: Contemporary Architecture from Southern California. 2013, Artforum 350 SEVENTH AVENUE ATTN: SUBSCRIPTIONS, NEW YORK, NY 10001 USA.

79. Lindsey, B. and F.O. Gehry, Digital Gehry. Englische Ausgabe.: Material Resistance Digital Construction. 2001: Springer Science & Business Media.

80. Woods, L. [cited 2010 23 February 2010]; Available from: https:/lebbeuswoods.wordpress.com/?s=high+houses.

81. Dehaene, M. and L. De Cauter, Heterotopia and the City. Public space in a postcivil society, 2008: p. 53-73.

82. Alonso, H.D., Exuberance, I Don't Know; Excess, I Like. Architectural Design, 2010. 80(2): p. 70-77.

83. Alonso, H.D., Impactful Disruption: Gathered Thoughts of a Distracted Mind. Architectural Design, 2020. 90(5): p. 50-57.

84. Alonso, H.D., et al., Xefirotarch: Excessive. 2007: HUST Press.

85. Leach, N. and B. Farahi, 3D-Printed Body Architecture. 2017: John Wiley & Sons.

Chapter 2 Literature study

2.1 Introduction

This chapter intends to construct the possible two parts of the cultural background and technology of the research project, and a preliminary description of the subject material. As a starting point, the pattern is a complex traditional thing. It is necessary to interpret the pattern from different perspectives, including its element composition, its relationship with historical development, and the formation and meaning of its connotation； Digital design and the development of non-standard geometric shapes have become more mature. In terms of characteristics, it is more complex and ecological, which is also a focus of this research.

2.2 Development of pattern

The pattern graphics are interpreted as the meaning of visual image design. The concept of patterns is divided into specific and general terms. The particular patterns are the reproduction forms of visual graphics that meet people's basic aesthetic needs. In contrast, general patterns are structures and forms that contain artificial symbols and unintentional traces left by natural forms. Graphic design is an essential part of visual communication. All designs related to beauty and art are subject to conditions such as craft materials and uses. In the study of the design and redesign of the pattern, the knowledge we need to understand includes:

(1) Understanding of the background culture of the pattern. Different cultures have different preferences for patterns, and designers need to take care of other aesthetic hobbies when redesigning.

(2) Understanding of the characteristics of the pattern. The pattern is usually based on geometric, animal, and plant images, and then the design should be appropriately creatively deformed according to specific needs.

2.2.1 Formation of patterns

China has a long history, and the development of traditional patterns has also gone through a long time. The Paleolithic "hill-top cavemen" used animal teeth to connect as a necklace; the polished antlers and bird bones are carved with sparse and dense lines. These very simple lines, although they cannot be counted as Pattern, but already has a certain decorative meaning. It is not difficult to see that in the long-term production and labor, the understanding of aesthetic concepts has begun to sprout slowly.

In the Neolithic Age, decorative patterns have been greatly improved, and they have been applied to all aspects of life and production, with a wide range and variety. According to the existing materials, the content of the ornamentation can be roughly classified into four categories: geometric, animal, plant and character patterns. Among them, geometric patterns are the most commonly used, followed by animal, plant and human patterns.

2.2.1.1 The geometric patterns

The geometric patterns of the Neolithic Age are mainly the regular arrangement and combination of the length, thickness, horizontal and vertical, zigzag, cross, density and dots of the line to form square grids, nets, ripples, triangles and circles. Patterns and other patterns.

The composition of these patterns is mainly derived from life and labor, but there are also many other factors. From the perspective of archaeological excavations, the creation and application of geometric patterns in the Neolithic Age are greatly influenced by weaving. Common patterns include the so-called basket pattern, cord pattern, mat pattern and woven pattern. At the Banpo, Jiangzhai, and Miaodigou sites of the Yangshao Culture, the bottoms and ears of the unearthed pottery bowls and pots were printed with cloth marks, and there were bone needles unearthed, which proved that the linen cloth and Silk fabrics and animal skins are sewn into garments. At the Neolithic site of Caoxieshan, Wuxian County, Jiangsu, three types of hemp fabric fragments were found, basically plain weaving[1]. In 1958, a batch of silk fabrics were unearthed at the Yangliangzhu Cultural Site of Qianshan Mountain, Wuxing, Zhejiang, including uncarbonized yellow-brown silk pieces and carbonized ribbons and silk threads that still have a certain degree of toughness. The raw material is silkworm silk, and the spun silk is plain weave. In 1957, at the Neolithic site of Talitaliha, Nuomuhong, Dulan County, Qaidam Basin, Qinghai, five pieces of brown- and yellow-colored striped felts were discovered [2]. The warp and weft threads of the fabric are interwoven regularly to form a variety of regular geometric patterns. Sewing thread marks, due to the thickness of the thread, the tightness of the stitches and the difference in the length of the connection, can form a wavy curve or a triangular fold line with different widths. Woven products made of various materials such as reeds, grate and wicker can be composed of various and regular geometric patterns.

For example, the weaving marks left on the pottery unearthed at the Jiangzhai and Banpo sites in Lintong, and the many weavings unearthed at the Hemudu and Qianshanyang sites, there are dozens of weaving patterns such as "human" patterns and braid patterns. And some of these weaving patterns were imitated on pottery, bones and other utensils at that time as decoration. Examples include the herringbone pattern pottery pieces unearthed at the Banpo site, the woven pattern piercer seat unearthed at the Yedian site in Zou County, Shandong, and the net pattern pottery back pot unearthed at the Dadunzi site in Pi County, Jiangsu, Wujiang, Jiangsu the rhombohedral bone artifacts unearthed at the Meiyan site. In Banshan, Machang-type painted pottery and printed pottery in the southeast, weaving patterns are more common. The second volume of "Selected Works of Plekhanov's Philosophy" pointed out: "In pottery decoration, we first encountered straight lines or polylines, squares, crosses, zigzag patterns, etc., this form is primitive art, starting from the more primitive handicrafts. Borrowed from weaving and braiding [3]." This statement is basically consistent with the original decorative arts.

The rope twisted with double strands and the rope braided with three strands are also interesting geometric patterns. The straw rope unearthed at the Caoxieshan site in Wuxian County is twisted in the same way as the modern one[4]. The Qianshanyang site unearthed a bamboo rope twisted from grate strips and a thick and thin rope twisted and twisted with two or three strands of ramie. And this kind of Jomon was also transplanted to pottery as decoration at that time. For example, many of the pottery fragments unearthed at the site of the Immortal Cave in Dayuan Dayuan, Jiangxi, have Jomon patterns. Some Jomon are arranged in disorder, both inside and outside. These may be the natural imprints left by the pottery utensils; some are neatly arranged, parallel and segmented, and the Jomon is painted with vermilion and engraved on the grid. These are obviously consciously used as decorations[5] Longshan and Liangzhu cultural pottery are decorated with tools that simulate rope making. In the long-term labor practice, primitive humans have learned to sew, twist rope and weave. They have touched it, observed it, improved it, and made it by themselves for thousands of times from generation to generation, so they naturally learnt in the art of pottery and jade. It is reproduced in the creation to express one's dexterity and ability[6].

In many Neolithic sites, snail shells and clam shells have been found. There are obvious spiral patterns on the snail shells, and the clam shells are regularly arranged in arcs. The snail-shaped pottery pots unearthed at the Dadunzi site in Pi County, Jiangsu Province and the spiral pottery decorations of the Qujialing culture are created by mimicking the image of snails. For example, the circle of the sun, the ray of fire, the fluctuation of water and the ups and downs of mountains, primitive people also often come into contact with them in life, and these are the source of their creation of geometric patterns. In this period, the sun patterns, flame patterns and water ripples engraved and painted on pottery, jade, teeth, and bones were a kind of artistic creation of primitive humans.

Some archaeologists believe that some geometric patterns gradually evolved from the images of animals and characters. Such as the fish pattern on Banpo-shaped painted pottery.

The early simple pattern slowly evolved into the later composite fish pattern, and then gradually evolved into the headless complex fish pattern, and after many changes, the geometric pattern was formed. When the concrete shapes become geometric shapes, they can have a variety of combinations and different changes.

The development of the bird pattern on the temple bottom ditch-shaped painted pottery[7]...from realism to freehand brushwork, to symbolism, from primitive characteristics to mature development, and then changed from a concrete bird shape to an abstract

geometric dotted line[8, 9].

On the Majiayao-type colored pottery, the bird pattern has a similar evolution from concrete to abstract[10]. On the Banshan and Machang-style colored pottery, there is a kind of humanoid pattern with the hands raised... From the realism to the geometric pattern, the early humanoid pattern gradually increased with the legs erected and the hind limbs gradually increased, and each joint had claws and fingers. In the late stage, the humanoid pattern was broken down into patterns composed of certain parts of the human shape. The head, body, and claw fingers disappeared one after another, becoming a geometric pattern composed of triangular fold lines.

The emergence of geometric patterns on pottery, jade, bone, teeth and other utensils in the Neolithic Age is mainly due to people's understanding of shapes in the long-term labor and production, which evolved through the combination of reasoning and art; they are constantly creating in practice, a sense of rhythm, rhythm and regularity are reproduced. It is an abstract concept of form, a point, line, and noodles that are rationally repeated, overlapped, crossed, and combined. Engels pointed out: "The concepts of lines, faces, angles, polygons, cubes, spheres, etc., are all derived from reality."[11] The cultural relics of Qujialing show that the spinning wheel color patterns are mostly composed of straight lines and arcs. Spinning patterns are mostly an imitation of spinning wheel rotation, a symbolic pattern of spinning at that time, and a direct reflection of people's spiritual life at that time[12]. When the color pattern of the spinning wheel rotates, it can not only produce a variety of beautiful rhythms, but also facilitate the observation of the speed of rotation, which is beneficial to production and more convenient to use.

It should be pointed out that geometric patterns are the most changeable, the easiest way, the easiest to adapt, and can achieve a better artistic effect. A large number of geometric patterns can be made only by the overlap, intersection, amount, and repetition of points and points, lines and lines, planes and planes, as well as the density, unevenness, inversion, and continuity of the arrangement. Then it is combined with points and lines, lines and surfaces, surfaces and points, or combined with natural shapes to form endless beautiful patterns. The pattern made has a unique rhythm and beauty of rhythm. It can be individually formed into a pattern, and it can be combined into a single piece. It is more flexible and superior to any pattern composed of animals, figures, and plants. Regardless of size, height, width, length, radius and straightness, density and simplicity, it can be adapted at will. Because geometric patterns have many advantages and advantages in composition and application, it is possible

to be widely used in primitive pottery, jade, teeth, and bones.

In addition, geometric patterns were used especially in this period, and have a certain relationship with primitive beliefs, totem worship and customs. Shi Xingbang's believes: "The main geometric patterns and patterns may have evolved from animal patterns. Representative geometric patterns can be divided into two categories: spiral patterns are derived from bird patterns, wavy curvilinear patterns and hanging patterns are evolved from frog patterns... The two types of geometric patterns are clearly divided into totem signs of different clans and tribes at that time. " "In the primitive society, pottery ornamentation was not only a decorative art, but also a manifestation of the material culture of the ethnic community.... Painted pottery ornamentation was a symbol of a certain community of people, and it was used as a clan totem on most occasions. Or other signs of worship." "According to our analysis, the geometric patterns of Banpo painted pottery are derived from fish patterns, and the geometric patterns of Miaodigou painted pottery are evolved from bird patterns." "The Banpo type and Miaodigou type of Yangshao culture belong to different tribes with fish and bird as totems, and Majiayao culture belongs to two clans with bird and frog as totems.[12, 13]"

Yan Wenming's "The Origin of Painted Pottery in Gansu" believes: "The frog patterns and bird patterns from the Banpo period to the Miaodigou period and then to the Majiayao period are linked, and they clearly exist[14, 15]. In the context of inheritance and successive evolution. At first, it was realistic, vivid, and diversified. Later, it gradually moved towards patterning, metricalization, and standardization. However, the two motifs of frogs and birds are consistent with each other." "...After a period of development, the bird pattern began to be swirled in the Majiayao period, while the swirl pattern of the Half-Mountain period and the large circle pattern of the Machang period, resembling the sun, can be called a pseudo-sun pattern. It is the continued development of the Majiayao type swirl pattern. It can be seen that the bird pattern is originally related to the pseudo-sun pattern."

In ancient Chinese myths and legends, there are many stories about birds and frogs, many of which may be related to totem worship. Later, the image of the bird gradually evolved into the golden crow representing the sun, and the image of the frog gradually evolved into the toad representing the moon. These are all the worship of the sun and moon gods, which are embodied in the patterns of painted pottery. The motif of this pair of painted pottery patterns can last for so long, which in itself shows that it is not an accidental phenomenon but is related to the beliefs and traditional concepts of a nation. "

In the Warring States and Qin and Han Dynasties, geometric patterns were generally used as auxiliary patterns on stone portraits, and some of the bricks were used as main patterns. On part of the portrait bricks unearthed in Henan, most of them used curves, straight lines and dots to form rhombus, square, rectangle, octagon, etc. as units, arranged in scattered points to form continuous patterns of two squares and four squares. The composition of this method is related to the use of impression printing methods in production, and the process is simpler and labor-saving, and good artistic effects can be achieved. In general, straight lines, polylines and curves are used to form geometric borders on the stone reliefs. The common ones are triangles, diagonal lines, rhombuses, grids and ripples, etc., forming two continuous patterns. The cloud and thunder pattern, fish scale pattern and heavy ring pattern that were popular in the slave society are very few in this period, and some have disappeared. The style is very different from the Shang Dynasty, Western Zhou Dynasty and Spring and Autumn Period.

In the Wei, Jin, Southern and Northern Dynasties, Sui and Tang Dynasties, no matter the patterns of plants, animals, and figures, they mostly contained Buddhist content, and geometric patterns also contained this meaning. Common patterns include flame pattern, flower rope pattern, hanging curtain pattern, Luo pattern, hanging bell pattern, zigzag pattern, etc., which are mostly used in grottoes, inscriptions, epitaphs and tiles. For example, flame pattern. Flame is a symbol of Buddhism in Buddhism, and it is used as decoration in Buddhist art. The flame pattern mainly composed of arcs is a distinctive feature of Northern Wei decoration, and it is also a new creation of Northern Wei craftsmen. The performance of Yungang Grottoes is simpler, and the performance of Longmen Grottoes is more complicated. The flame patterns of the Lotus Cave and Binyang Cave are the most exquisite, and the rising fire is real and vivid. In the Eastern, Western Wei and Northern Qi periods, the flame pattern gradually became simpler. (Figure 2-1，Figure 2-2)

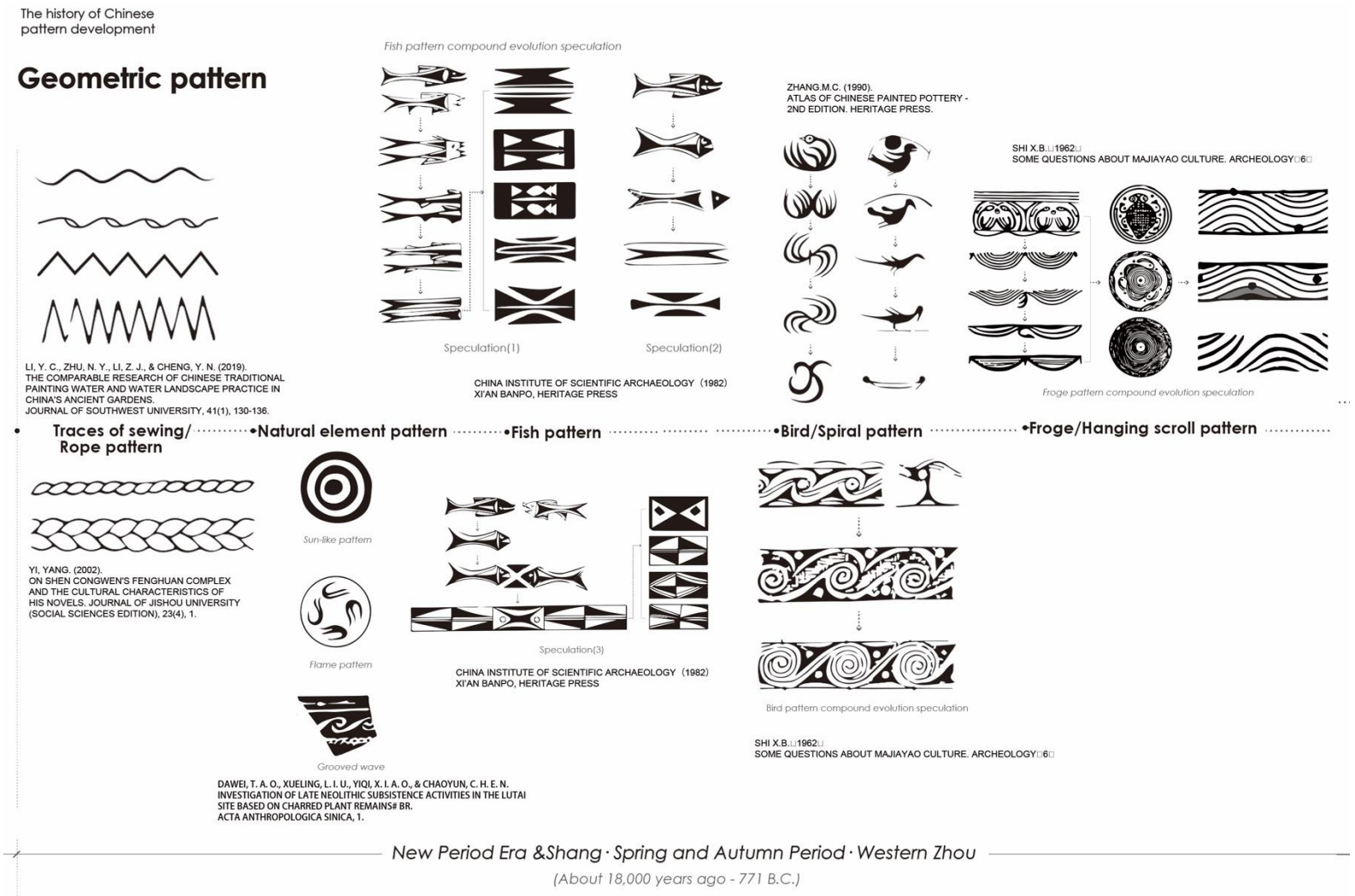


Figure 2-1 The development of geometric pattern (1)

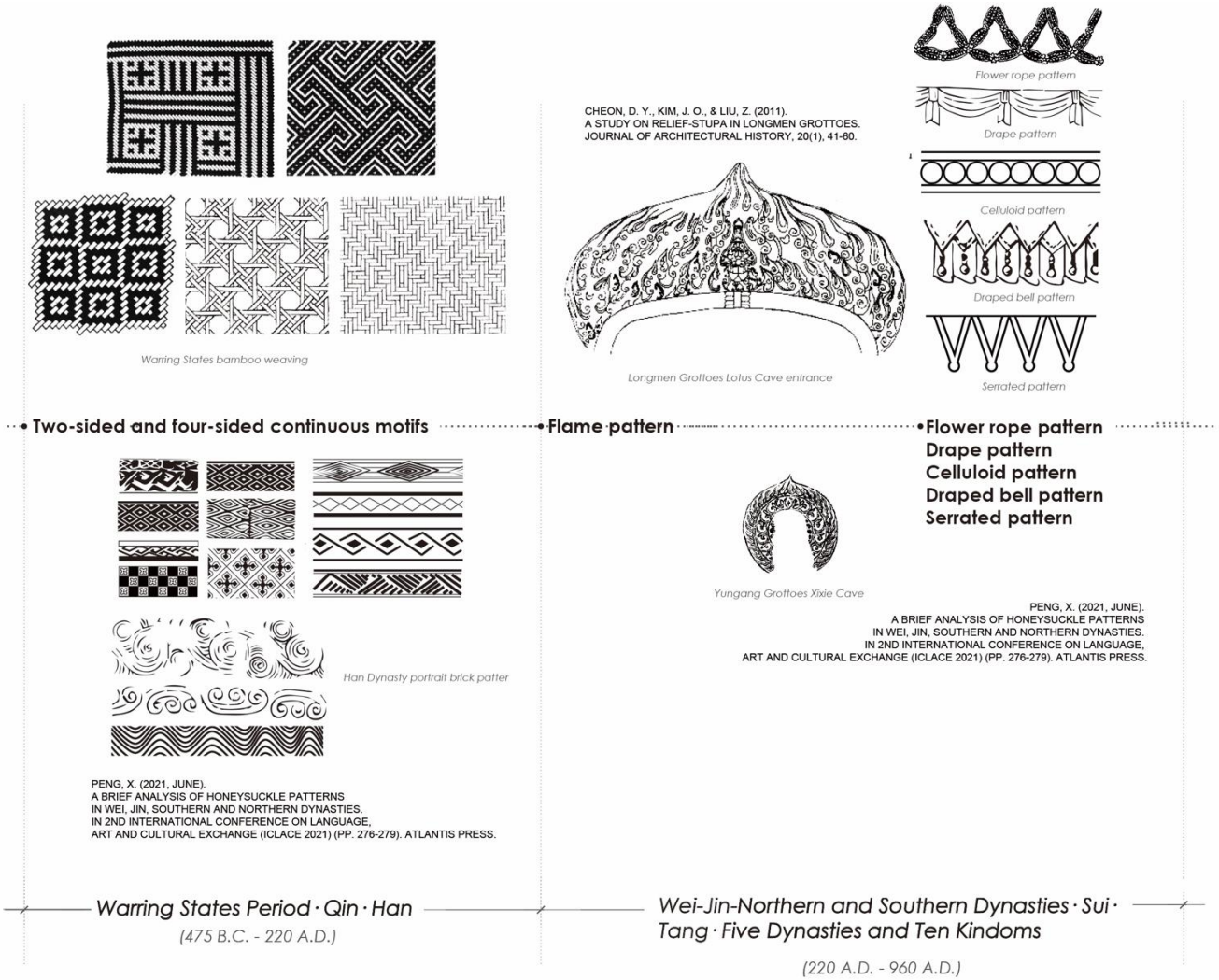


Figure 2-2 The development of geometric pattern（2）

2.2.1.2 The animal pattern

Common animal patterns include fish patterns, bird patterns, frog patterns, animal patterns and animal face patterns.

The fish pattern is the most representative of the Banpo-type colored pottery unearthed from the Yangshao culture. A large number of fishing tools were unearthed at the Banpo site. It can be seen that fishing is an important production activity in the lives of Banpo residents. The various fish patterns on the painted pottery, some resemble carp, some resemble swimming bream, some resemble silver carp, some resemble salamander, and compound fish, reflecting the familiarity of people with fish at that time. The image of fish is general, concise and exaggerated. The woodcarving fish and jade fish unearthed from the Hemudu site in Yuyao, Zhejiang and the Liangzhu site in Fanshan, Yuhang, are more realistic[13, 16, 17].

The bird pattern is the most abundant in temple bottom ditch pottery. They have their heads looking for food, spread their wings and want to fly, soar in the air, stand upright, stand up and look around[18]. They are of different shapes and lively and vivid. There are colored paintings and plastic decorations. The double-bird pattern painted on the Shilingxia-type colored pottery has its mouth and eyes facing each other, and its wings spread out, like playing or rushing for food. The bird pattern on the Majiayao pottery pot has a streamlined body, and the bird feathers are round, as if flying against the wind. The Hemudu cultural tooth carving is engraved with a double phoenix and Chaoyang pattern; the bone is engraved with a double-headed bird pattern, which is a peculiar composition. The jade bird, jade eagle, jade eagle and jade bird ornaments of Liangzhu Culture and Hongshan Culture are some realistic, some exaggerated, and some concise.

Frog pattern is a common pattern in primitive decoration. The earliest unearthed from the Jiangzhai Banpo site in Lintong, Shaanxi, is also more realistic. The frog patterns unearthed at the Miaodigou site in Shanxian County, Henan Province are more exaggerated; the Miaodigou-shaped frog patterns unearthed in Jingcun, Wanquan, Shanxi, were carved with cones. This technique of expression is rare. Majiayao-shaped frog patterns unearthed at the Majiayao site in Lintao, Gansu, have gradually been patterned. The variant frog patterns on Banshan and Machang-style colored pottery gradually evolved into geometrical shapes. The frog pattern changes from realism to exaggeration, deformation, and then geometrical.

The half-slope fish pattern, the temple bottom ditch type and the Majiayao type bird pattern gradually change from concrete images to abstract ones, and their development and evolution laws are roughly the same. The image of the Liangzhu culture jade frog unearthed from the Zhanglingshan site in Wu County, Jiangsu Province is very realistic.

Animal patterns, such as deer patterns and pig patterns, are found in Banpo type, Hemudu culture and Shilingxia type sites. Banpo painted pottery with deer patterns, some stand and look around, some run. According to the investigation of archaeologists, the main hunting objects of Banpo residents were deer. Decorative objects of pigs were unearthed in Hemudu, Banpo and Dawenkou sites. Hemudu pottery bowl pig pattern, the pig body is carved with flower-shaped patterns; an unearthed pottery plastic pig has an image that resembles a modern domestic pig. Pottery pig head decoration was also unearthed at the Banpo site of Hejiawan, Xixiang, Shaanxi in 1982[19]. Animal facial patterns are found in Liangzhu Culture, Longshan Culture and Banpo-shaped artifacts. The Liangzhu culture has the most changes and the most typical. There are animal face patterns on jade cong, jade Huang and jade plates unearthed from Liangzhu cultural sites such as Yaoshan Mountain and Fanshan Mountain in Yuhang, Zhejiang. They generally have prominent eyes, large mouths, and some show teeth. The stone adze unearthed at the Longshan cultural site in Rizhao, Shandong, and the animal face pattern on the jade of the Longshan culture collected by the Fogg Art Museum in the United States have been geometricized.

In the Warring States and Qin and Han Dynasties, the animal patterns on the portrait tiles and stone portraits included horses, tigers, leopards, deer, elephants, bears, wolves, lemurs, monkeys, dogs, rabbits, chickens, ducks, cranes, wild geese, eagles, scorpions, bird,

The animal patterns on ceramics in the Song, Yuan, Ming, and Qing Dynasties mainly include fish, birds, dragons, and phoenixes. The fish pattern developed to the Song, Yuan, Ming, and Qing periods, and the fish pattern was used as the theme pattern on the porcelain[17]. The fish patterns of the Song Dynasty have a strong decorative taste, and they are often combined with lotus flowers. During the Yuan, Ming, and Qing Dynasties, the fish patterns were more realistic and often decorated with algae. The fish patterns of this period are common carp, catfish, mandarin, crucian, etc., and some are painted together.

Bird pattern. Various bird patterns were popular on porcelain in this period. The bird patterns of Song and Yuan Dynasties are all decorative, and they are mostly realistic Chinese paintings in the Ming and Qing Dynasties. The common ones are mandarin ducks, white heads, wild geese, magpies, thrushes, longevity bands, Baige, parrots, cranes, ducks and so

on. Geese and migratory birds fly to the north every year after the equinox and return to the south after the equinox. They fly in order. This is a combination of folk customs and bird habits. Various bird patterns are usually combined with various flowers, plants and water patterns to form a picture, such as mandarin ducks playing in the water, double ducks in lotus ponds, auspicious clouds and flying cranes and spring flowers and double birds. The patterns are multi-balanced composition, which is vivid and lively. In terms of highlighting themes, plot processing, and false and real references, they all have a certain degree of law, which is appropriate and complete.

Dragon pattern. The dragon was revered as a god six to seven thousand years ago. Feudal society, as a symbol of imperial virtue, is the highest auspiciousness. As the times change, there are various manifestations. The dragon patterns of the Neolithic and Shang and Zhou Dynasties resemble snakes, some with horns, some with feet; in the Han Dynasty, some resemble beasts, some with snake bodies, four feet, claws, horns, and long tails, with double wings.

In the Tang Dynasty, the dragon pattern opened its mouth and stretched its tongue, and its horns resembled antlers, making it stretched out and danced. In the Song and Yuan Dynasties, the beard stretched out and tongue was mostly three claws. In the Ming and Qing Dynasties, the teeth and claws were stretched out, dull and cumbersome, and five-clawed dragons. In the Song, Yuan, Ming and Qing porcelains, many dragons are used for decoration, including single dragon, double dragon and pan dragon. Most of them are used as main patterns, decorated on prominent parts such as bottles, plates, bowls, etc., and are often combined with auspicious clouds, treasure beads, sea waves and wind birds to form various implied patterns. Most of these decorations were newly created during this period[20].

The phoenix is revered as the king of birds, symbolizing auspiciousness. There are wind patterns in the past dynasties, which are different from generation to generation. Shang and Zhou wind patterns, long tail, one foot, crown, and mostly static shape. The Warring States, Qin and Han Dynasties became two-legged, with the tail lifted up, and more dynamic depictions. During the Sui and Tang Dynasties, the crown of the head was made into a cloud shape, and the tail feathers were curled and shaped like petals. Song, Yuan, Ming, and Qingfeng patterns, chicken head and eagle beak, scales, long tails, increased tail feathers, most of them are five-pointed, a few three-pointed or seven-pointed, most singular, even rare, composition has a strong decorative nature, obviously showed a different style from the previous period. On the porcelain of this period, the wind pattern is one of the popular

patterns, and the composition is diverse. The subject matter expands, usually as the main pattern, decorated in the main position. (Figure 2-3，Figure 2-4)

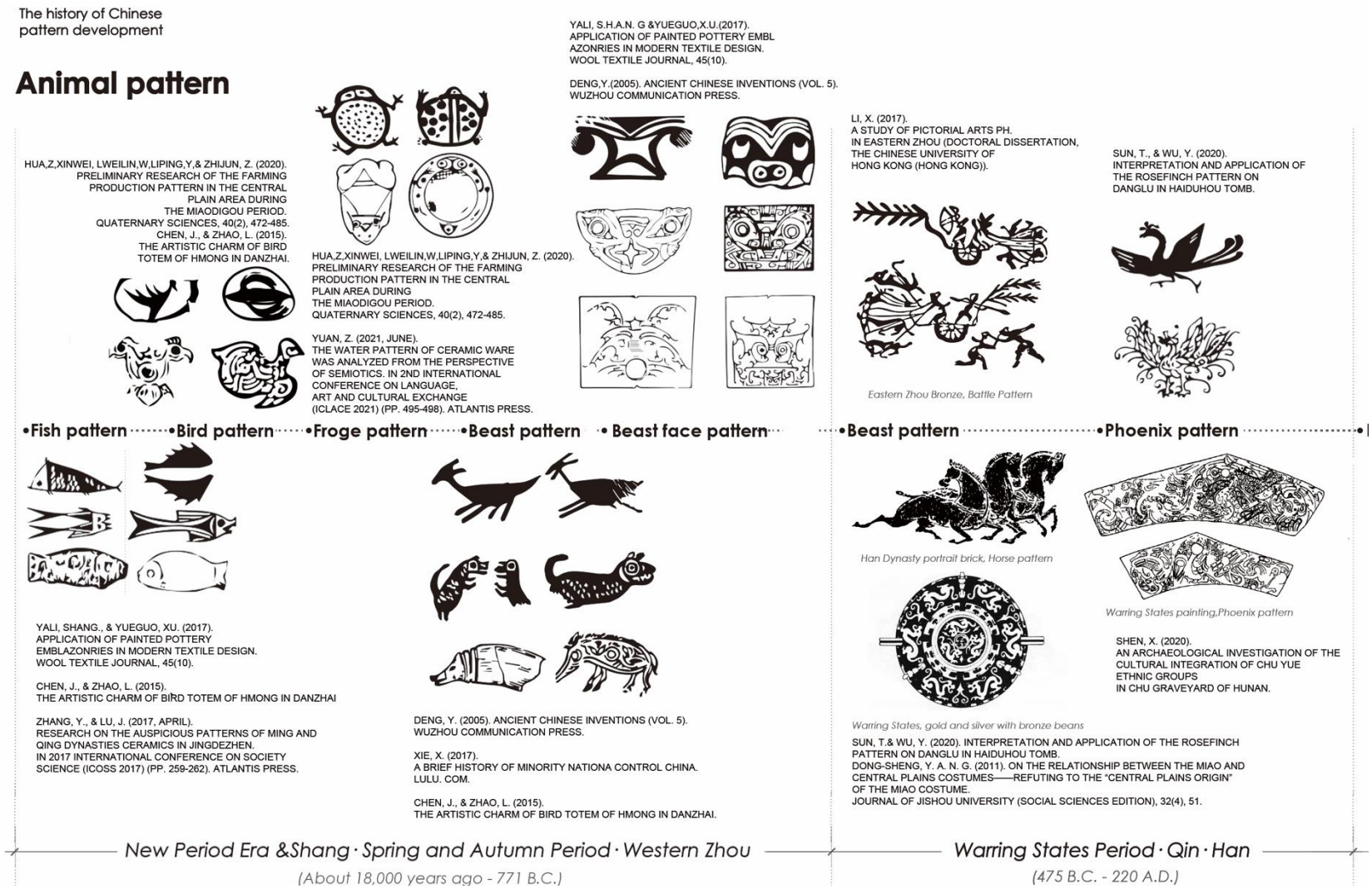


Figure 2-3 The development of animal pattern (1)

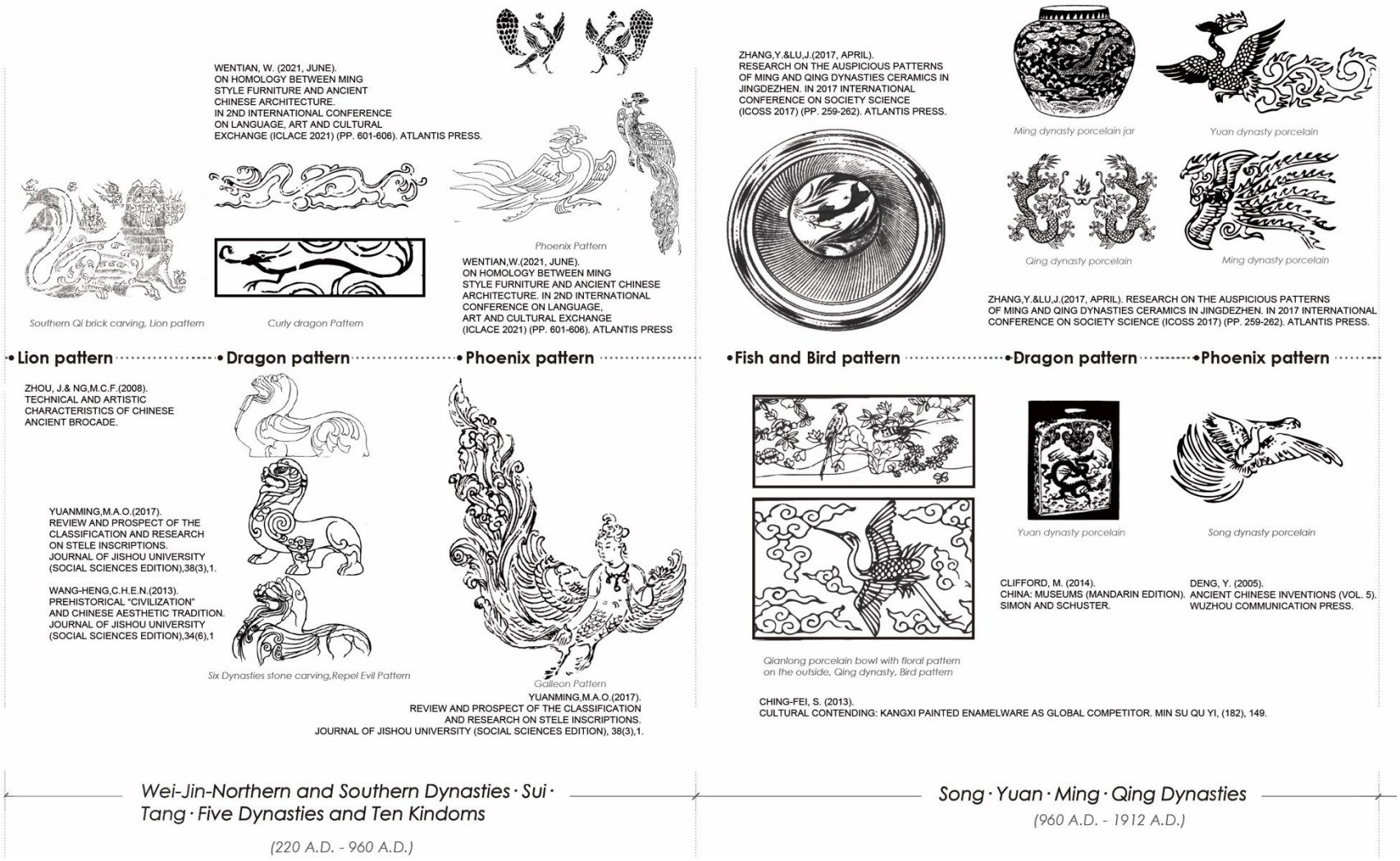


Figure 2-4 The development of animal pattern (2)

2.2.1.3 The plant pattern

Plant patterns are also widely used in primitive decorative art. There are mainly grains (leaves), ears of rice, trees and petals. The depictions are more vivid. Archaeological excavations have shown that the production in many areas of the Neolithic Age was dominated by agriculture. At the Hemudu cultural site in Yuyao, Zhejiang, a large number and variety of plant fruits, branches, leaves and rice were unearthed. The rice has been identified by the Beijing Institute of Botany and Zhejiang Agricultural University as an artificially cultivated rice. This is the earliest cultivated rice discovered in our country. Among the plants are the fruits and pits of pine, Chinese cedar, Liquidambar, hemp reed, water chestnut, gourd, wild jujube, peach and melon. Wuxing Qianshan Yangliangzhu cultural site also unearthed rice, and the identification confirmed that there are two varieties of japonica rice and indica rice. Primitive humans are familiar with many plants during their long-term gathering and clothing industry labor. According to investigations, primitive humans have a particularly keen ability to observe the main foods that they depend on for survival, such as grains and animals. Therefore, the plant images portrayed on pottery and other objects are particularly exaggerated. For example, the plant images on the pottery of Yangshao and Dawenkou cultures are like rice, leaves, and petals. They are general, exaggerated and vivid. Hemudu culture pottery with rice ear patterns, plump and realistic; four-leaf and five-leaf patterns, plump and strong. The tree pattern of the Banpo-shaped colored pottery painting is simple and concise. All these are a reflection of the development of agriculture to a certain level at that time.

In the Warring States and Qin and Han Dynasties,Plant patterns include tree patterns, lotus patterns, plum patterns, branches and leaves patterns, and crop patterns[21].

Tree-pattern portrait bricks and stone portraits were unearthed in Wu's shrine in Shandong, Xuzhou in Jiangsu, Deyang in Sichuan and Suide in Shaanxi, etc. Although their performances are different, they all have strong decorative properties. There are symmetrical, balanced, suitable, and unsuitable. Judging from the specific images of various tree patterns, some can be identified as mulberry, willow, etc.

Lotus pattern. The algae wells unearthed in Luoyang, Henan and Yinan, Shandong are decorated with lotus-shaped patterns. There are those for the main pattern and the ones for the edging. The lotus pattern unearthed in Luoyang is the most vivid depiction, and is

decorated with lotus, lotus seeds and lotus buds.

Plum pattern. The plum pattern on the portrait bricks unearthed from Zhougong Temple in Luoyang, Henan Province clearly depicts the five-petaled plum blossoms, and the image is full. Because it is used as a border pattern, the composition is regular, and some are combined with group birds, which is relatively rare.

The leaf patterns on the portrait tiles of Yuxian County, Henan Province are composed of four leaves in a radial pattern, forming a unit pattern, and are arranged together with the geometric pattern. On the stone portraits unearthed in Shaanxi, there is a common two-sided continuous pattern composed of plant branches and leaves. The basic shape is a wavy curve, which constitutes a fluent and unique image.

Jiahe pattern. The pattern on the stone relief unearthed in Suide, Shaanxi is the most typical. Tangzhihua portrait bricks were unearthed in Wanxian City, Sichuan. This is the first case of tangled flowers. The middle is a bottle, the flowers grow out of the bottle, and they are divided to the left and right, symmetrical. The branches of the flowers are described as wavy vines, and the flowers emerge from the waves, and the combination is more regular. This flower shape already has the characteristics of tangled branches. The twisted branches pattern is often used as the main pattern in the decoration of the subsequent dynasties.

In the Wei, Jin, Southern and Northern Dynasties, the plant patterns of the Sui and Tang Dynasties, there are various patterns of twisting branches, lotus patterns, honeysuckle patterns, and peony, grape and grass leaf patterns. Among them, the patterns of Tangzhi, Lotus and Honeysuckle have the most changes.

Twisted branches pattern, called "Wanshou Teng" in ancient times, also known as Tang grass and vine pattern. During the Wei, Jin and Southern and Northern Dynasties, with the prosperity of Buddhism, the pattern of tangled branches became popular, which may be related to the meaning of "recurring and endless". The twisting patterns of the Yunwang Grottoes are mostly working from the early Northern Wei Dynasty, with simple organization and numerous forms; the twisting patterns of the Longmen and Gongxian Grottoes are sculptures from the late Northern Wei Dynasty and the Eastern Wei Dynasty. The branch patterns are fluent and vivid; the Tang dynasty's tangled branches pattern is gorgeous and colorful; the completeness of the composition and the richness of changes are unprecedented in previous generations. The twisted branches pattern has been diversified

by artists in the Han Dynasty, the Wei, Jin, the Southern and Northern Dynasties, and the Sui and Tang Dynasties.

Lotus pattern. The ancient name of lotus is lotus or hibiscus, now it is called lotus. When in full bloom, the flowers are larger, with distinct veins and beautiful shapes. When the fruits are in bloom, they are ornamental and edible, and the branches and leaves are simple and round. Many works believe that the decoration of lotus flowers began in the Wei and Jin dynasties after Buddhism was introduced to our country. According to archaeological excavations, as early as the Eastern Zhou Dynasty, the lotus pattern has been used more. During the Warring States Period, there were more decorations made with lotus flowers, and many pieces were unearthed from the Warring States Tomb in Jixian County, Henan. The decoration field of the Han Dynasty expanded. Painted pottery, portrait bricks and algae wells were all decorated with lotus patterns. Among them, the lotus pattern of the portrait bricks unearthed from the Han tomb in Luoyang, Henan was the most representative, with flowers, buds, solids, stems and leaves. The constituent elements are concrete and vivid. Since the introduction of Buddhism, the lotus flower, as a symbol of Buddhism, represents the "pure land" and symbolizes the "highest purity". Therefore, the lotus flower has become one of the main decorative themes in Buddhist art. Especially in the Wei, Jin and Southern and Northern Dynasties, it flourished with the spread of Buddhism. Due to the introduction of passionflower at that time, the variety of lotus flowers increased, coupled with its own decorative flowers, lotus houses, leaves, stalks, and lotus roots. As a result, various lotus patterns can be seen everywhere in religious objects, and they have also become daily use. A decorative theme commonly used in utensils. In the Longmen Grottoes period of the late Northern Wei Dynasty, the scope of application was gradually extended to niches, arch pillars, cave ceilings, grounds, Buddha seats, etc., all decorated with lotus flowers, which became a distinctive feature of Longmen Grottoes decoration. In the center lotus at this time, there is no significant difference in the overall width of the lotus petals. The lotus is larger, and the lotus seeds are carved. When the whole pattern is cross-sectioned, the four convexities do not change much, and the lotus petals with wider fat and no treasure appear. During the period of the present county grottoes in the late Northern Wei Dynasty and the Eastern Wei Dynasty, the application range was wider, and the lotus pattern changed more. There were as many as 20 kinds of lotus patterns in Pingqi in the first cave alone. At this time, the center of the big lotus, the lotus petals are moderately wide and narrow, and the unevenness is not obvious. It has the form of a treasure, without a lotus core in the center. In the center of the lotus and the leaf patterns around the lotus, there is a form of rotation. The center of the lotus pattern in the early Sui and Tang dynasties also has this form of rotation, which has a strong sense of

movement. In the Northern Qi and Northern Zhou periods of the late Northern Dynasties, the lotus pattern was more commonly used, not only for grotto decoration, but also for painting, tile and tomb carving.

Honeysuckle pattern. Honeysuckle is a kind of twining plant, commonly called "honeysuckle" and "golden and silver vine". The composition of the honeysuckle pattern varies with the times. Composed in unit form, the bottom is round petals curled downwards, the top is like an orchid leaf, and the middle is a leaf-like petal, like a honeysuckle flower that is in bud.The Yungang and Longmen Grottoes are decorated with honeysuckle patterns as circular backlights and edges. Some of the composition resembles the side shape of a blooming honeysuckle flower; some uses a geometric shape as a skeleton with a honeysuckle pattern in the middle. There are also bird and beast patterns in the honeysuckle organization. On the Dunhuang patterns of this period, there are also many honeysuckle patterns in various ways.

The main plant patterns in the Yuan, Ming and Qing dynasties were floral patterns, with peony, lotus, plum, and chrysanthemum being the most common, followed by various entwined branches and flower and fruit patterns. Some floral patterns are often combined with various birds, insects, animals and figures.

Peony pattern. Peony has many changes in flower shape, with dozens of flowers, hundreds of flowers, and even more than a thousand flowers. It is a famous ornamental plant. Peony is known as "the flower of wealth", "the king of flowers", and "the first fragrance in the world", which symbolizes wealth and good fortune. Many Chinese poets use it as the theme to write poems. Peony has been used as decoration in Tang Dynasty. The peony patterns shown on the porcelain of the Song, Yuan, Ming and Qing dynasties are realistic and decorative; there are broken branches, scattered flowers, and entangled branches; there are separate and continuous ones; there are monochromatic and colorful ones. No matter painting, engraving, marking, distinguishing, carving, all show the characteristics of peony. Especially in terms of styling changes and performance techniques, it is rich and colorful, and it is one of the most characteristic and most varied decorative patterns in the flower patterns of this period[22].

Lotus pattern. It has been decorated on bronzes in the Eastern Zhou Dynasty. During the Southern and Northern Dynasties and the Sui and Tang Dynasties, the lotus flower was used as the symbol of Buddhism. Before the Song Dynasty, the lotus pattern mostly formed a top-

down round shape, with a lotus heart in it, lacking variation, and relatively monotonous. In Song Dynasty, lotus flowers often form side shapes with lotus leaves, lotus pods, etc., which are varied and lively. In the Song Dynasty, the lotus pattern was highly decorative, and the Yuan Dynasty gradually transitioned to realism. The Chinese painting form in the Ming and Qing Dynasties was the mainstream.

Plum pattern. Plum blossoms have been used for decoration very early. On the Han Dynasty portrait bricks unearthed at Zhougong Temple in Luoyang, Henan, there are plum patterns. Plum blossom patterns are common on porcelain in the Song, Yuan, Ming and Qing dynasties. In the Song and Yuan Dynasties, there were more broken branches, and the composition was sparse and more realistic in the Ming and Qing Dynasties, and the performance was fuller. Some plum patterns are combined with pine and bamboo to form a lucky three friends (pine, bamboo, and plum) pattern[23].

Chrysanthemum patterns in the Song Dynasty are rare; there are multiple forms of combination and individual in the Yuan Dynasty; chrysanthemum patterns in the Ming Dynasty gradually increased. This is influenced by the decoration of traditional Chinese painting at that time. On the fabrics of the same period, chrysanthemums are also commonly used as decoration. The chrysanthemum on the Ming brocade is one of the popular patterns at that time[24].

Over the branches of flowers. It was newly created in the Qing Dynasty and was generally used for decoration on porcelain plates and bowls in the Qing Dynasty. The so-called branch is to use a pattern to draw from the inner wall and stretch to the outer wall. This technique is called "Branch Flower". Tangle branches pattern. The Wei, Jin, Southern and Northern Dynasties and Sui and Tang Dynasties have been extremely popular, to Song, Yuan, Ming and Qing, the subject matter content is more expanded, and the composition forms are more diverse. There are tangled peony, lotus, chrysanthemum, grapes, miscellaneous flowers, melons and fruits, grass and leaves, and some are interspersed with characters, birds and beasts to make them more vivid and interesting. The combination of several main curves is interspersed with nature, balanced and moderately, with rhythm in rhythm and law in freedom. (Figure 2-5，Figure 2-6)

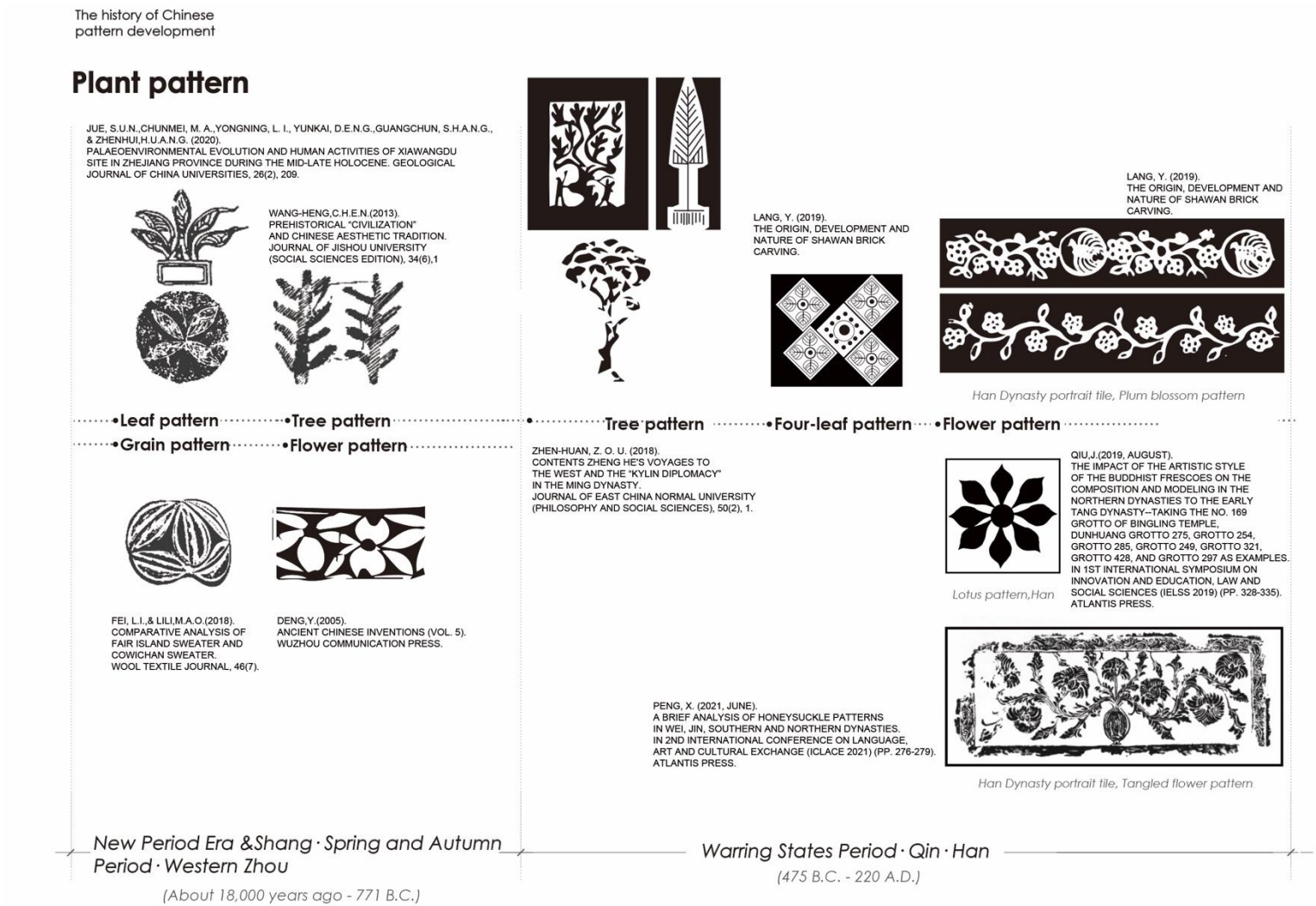


Figure 2-5 The development of plant pattern (1)

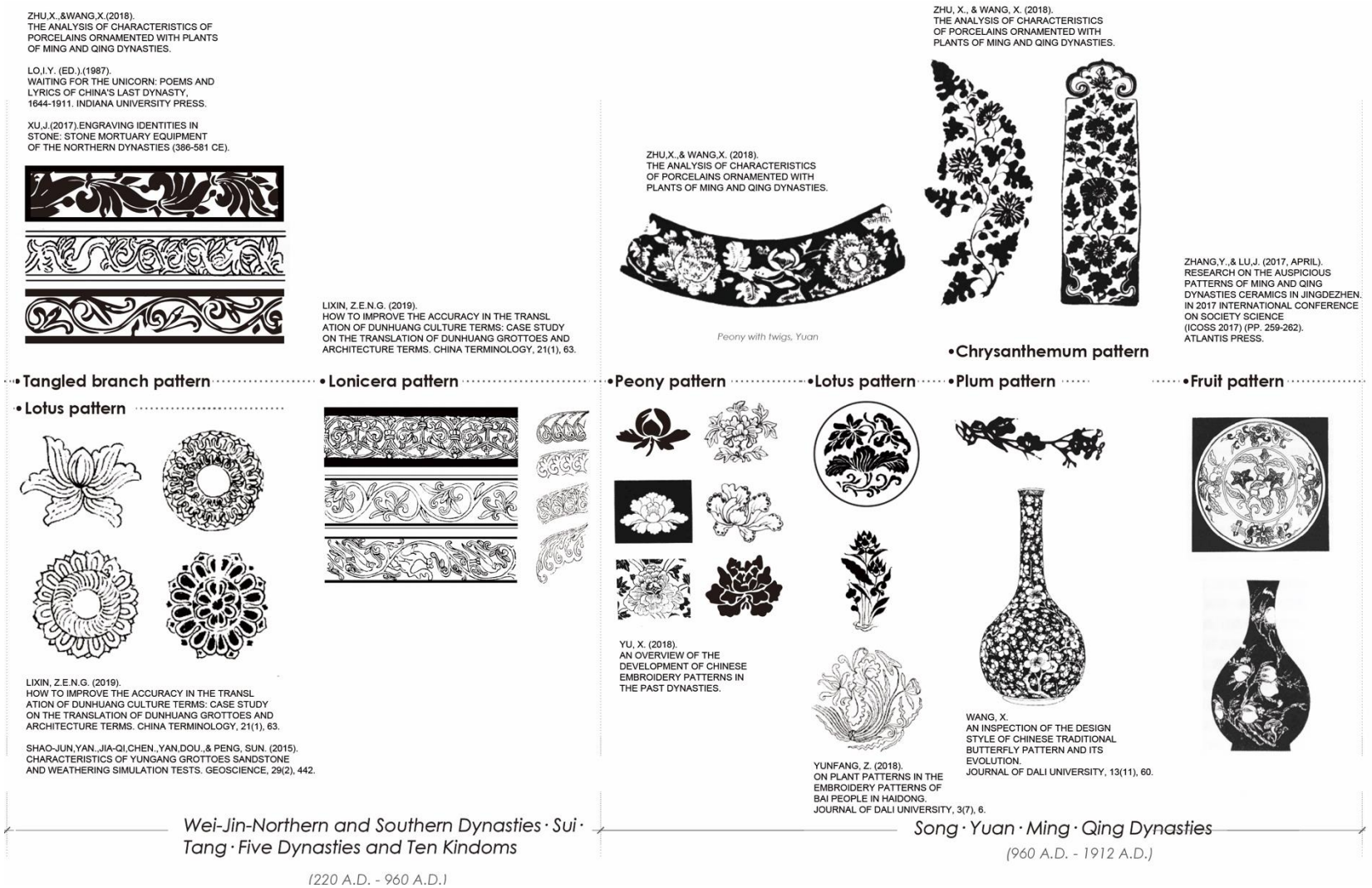


Figure 2-6 The development of plant pattern (2)

2.2.1.4 Figure pattern

Figure patterns can be roughly classified into two types: full-body figure patterns and human face (head) patterns.

The whole-body figure pattern is found on Majiayao-type, Banshan-type, Machang-type pottery and Liangzhu cultural jade ornaments, such as the dance pattern on the Majiayao-type colored pottery basin. Which is a group of five, a total of three Group. The characters hold hands with each other, their heads turned to one side, and there is a slant on each side of the head, which seems to be braids or ornaments; the two arms of each group are drawn in two lines, which seems to reflect the larger and frequent dance movements of the two arms[14, 25] . On the Liangzhu cultural jade ornaments, there are many human-shaped patterns carved out, one unearthed from Zhaoling Mountain, the human body is inverted, the foot is carved with a bird shape, and the image is strange. The jade ornaments unearthed from the Fangshan Mountain and Liangzhu Sites of Yaoshan Mountain in Zhejiang Province and the Liangzhu jade crown ornaments from the Nanjing Museum's collection are all engraved with gods, humans and beasts.

Human face decoration is more common, found in Banpo type, Miaodigou type, Banshan type, Machang type and Longshan cultural pottery, bone and jade. The human face pattern painted on the Banpo-shaped colored pottery basin can clearly depict the facial features, and there are many patterns on the face. Banshan and Machang-shaped human head-shaped mouthpieces have animal skins like tigers, leopards or lynxes painted on the human faces[26-28]. Some people think that this is a reflection of people's preference for whale tattoos at that time. Some believe that the "image and characteristics of human head images on the pottery of Banpo site...are images decorated by clan members during major religious sacrificial activities held by clan tribes." On the top of the head is a non-thorn-like pointed object, a hat with a garnish, the sides and corners of the face, the fish-shaped pattern painted, may be the representation of a totem tattoo [29, 30]. The pattern of fish in people's mouth is that at the beginning of the fishing and hunting season, people expressed their desires with pictures in order to pray for a larger amount of production." Some people also believe that the head-shaped patterns on the Banshan and Machang-type colored pottery are consistent with the tribal tattoo patterns at that time. This phenomenon has been confirmed by folklore data. Banpo-shaped bone carvings on the human face, the image is exaggerated. The mouth of the miaodi ditch-shaped colored pottery bottle is carved with a human head,

and the image is realistic. The jade ornaments of the human face in Longshan culture generally have round eyes, a big nose and a big mouth, two earlobes, and some show two fangs, which are similar to the taotie patterns of the Shang and Zhou Dynasties.

Character patterns in the slave society mostly focused on dynamic outlines. The mouth, eyes, ears, nose and inner activities of the characters are almost invisible. The various character patterns on the portrait bricks and stone portraits of the Han Dynasty are not only detailed, but also highly decorative. The content mostly describes the lives of noble landlords, such as feasting, singing and dancing, arsenal and hunting, etc.[31]; some are based on mythological stories and historical figures; some show scenes of production and labor at that time, including pictures of production labor. The most valuable, the most common content such as travel, a hundred shows, and hunting.

Many portrait tiles and stone portraits with dancing patterns are unearthed in various places. The common feature of the patterns is that the dancers are all "long sleeves", which is the characteristic of dances in the Han Dynasty. The portrait of Fuxi Nuwa is one of the common themes of patterns in the Han Dynasty. In ancient mythology, Fuxi Nuwa were the ancestor gods of human beings, and the ancients believed that they could protect the dead. The images on the portrait bricks and the portrait stones are made of human heads and snake bodies. Fuxi males hold the sun with their left hand, and the right hand holds the rules; female females hold the moon with their right hand and the left hand holds the rule. It symbolizes the principle of jurisprudence, as the saying goes: "Without rules, there can be no squares", that's what it means. The stone portrait of Yuren[32] was unearthed in Yinan, Shandong and Suide, Shaanxi. Usually with wings on the back, flying in the air, with a lively posture. This kind of feather man may be the predecessor of "Flying" in the future.

Character patterns have been used as themed patterns to decorate the main parts in the past dynasties. The character patterns on the painted pottery of primitive society are very simple graphics; the character patterns on the bronzeware of the slave society focus on dynamic outline; the Han Dynasty in the early period of feudal society has reached a certain level in expressing the inner activities of the characters. In the Wei, Jin, Southern and Northern Dynasties and the Sui, Tang and Five Dynasties, the characterization of the characters has been more in-depth, creating a brand-new style. The character patterns of this period are mostly related to Buddhist content. The common ones are flying, offering people, and various figures. The decorative patterns such as feasts, games, hunting, and traveling, which were popular in the Han Dynasty, have become rare.

In the Sui and Tang dynasties, most of the lines of figure carvings were outlined by single lines, which looked like iron lines. The conciseness, uprightness, and sturdiness of the line, the correct outline, the balance of the layout, the vivid expression and the outstanding character, have greatly surpassed the previous generation and have new creations. Although the lines are all the same thickness, due to the expressive power of the line, the rigidity and softness of the line and the transition are enough to show the image without the help of coloring. The edges of the characters are decorated with tangled branches, cirrus clouds and precious flowers, and the space of the characters is lined with flowers, stones and birds, which makes the picture fuller and uniform, and has a strong decorative taste. This character pattern is the inheritance and development of the character pattern of the Warring States Period and the Han Dynasty.

Figure decorations with Buddhist content that were popular in the Southern and Northern Dynasties, Sui and Tang Dynasties have been rare in the Song, Yuan, Ming and Qing dynasties. The themes describing children, ladies, gods, allegorical patterns and drama stories are more common. Character patterns are used as thematic patterns. The Song Dynasty mainly used various patterns for children, such as Cuju, circus, kite flying, puppet playing, and duck driving in the lotus pond. In the Yuan Dynasty, there are many patterns that reflect the stories of operas. These characters of operas reflect the prosperity of Yuan Zaju at that time. At the same time, they also show the porcelain decoration with opera stories as the content, which has been quite popular in the Yuan Dynasty. In the Ming and Qing Dynasties, allegorical patterns and opera paintings became more popular. The allegorical patterns composed of characters include Eight Immortals, Baizi, Shou Xing, Yu Qiao Geng Du and Dong Fang Shuo, etc. Opera stories include "Romance of the Three Kingdoms", "Water Margin", "West Chamber" and "Dream of the Red Chamber". In the Qing Dynasty, the porcelain figure paintings from the Kangxi and Qianlong periods are more exquisite. (Figure 2-7，Figure 2-8)

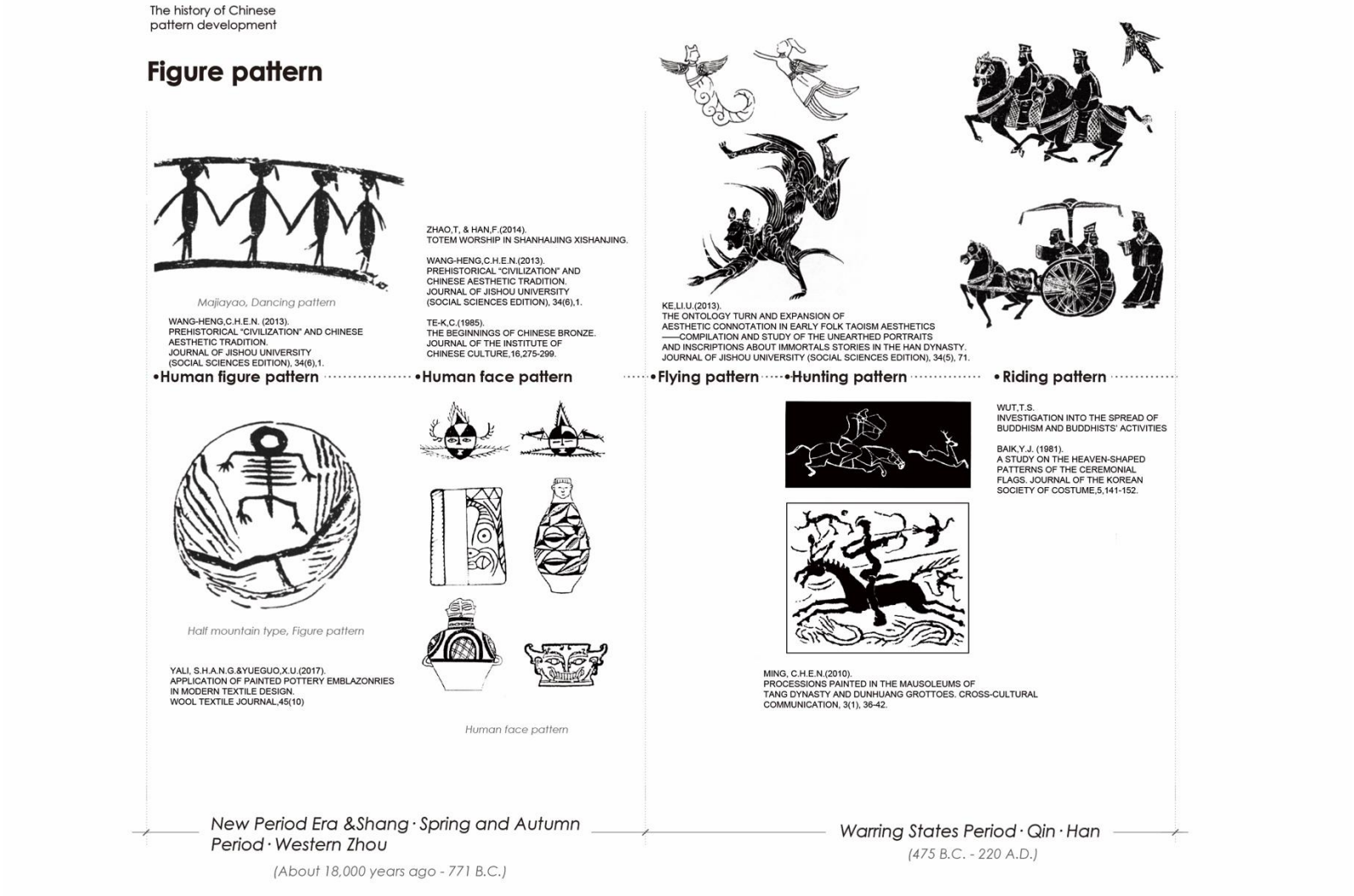


Figure 2-7 The development of figure pattern (1)

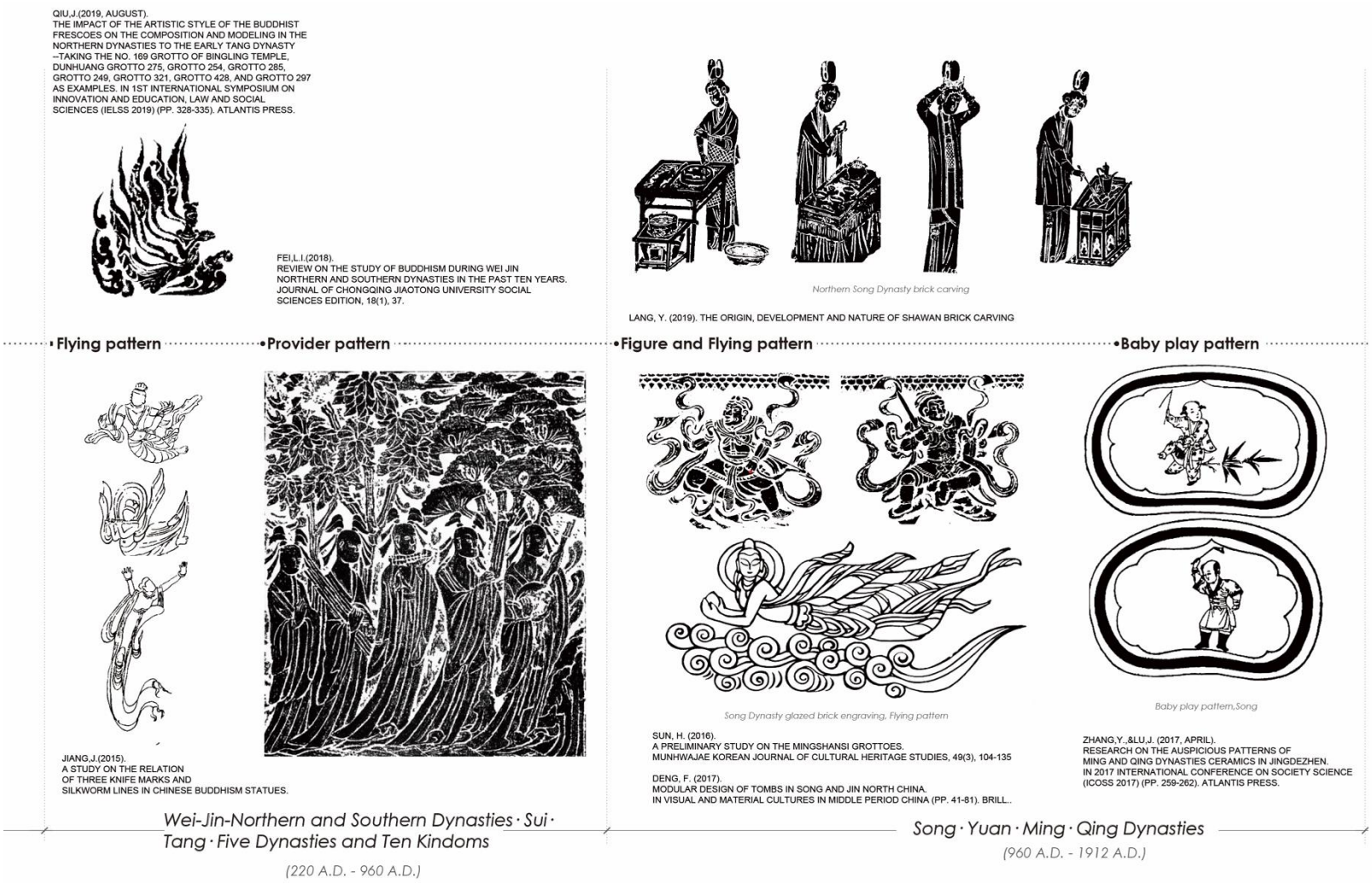


Figure 2-8 The development of figure pattern (2)

2.2.2 The relationship between patterns and society

In the process of historical transmission, patterns are the symbol carriers of cultural visualization. As one of the components, patterns also have corresponding characteristics, intentionally displaying Chinese society and culture characteristics and reflecting the mode of everyday life. The origin of patterns and language are broadly similar, and there is an essential connection between language research and pattern research. The function of language is communication, and the graphic design of patterns also transmits information. Decorative research such as pattern design can easily join the ranks of cultural and language research. J.B Waring proved that the simple patterns on the prehistoric pottery that have become the subject of research could be interpreted as symbols of the sun. All decorations have the role of symbolic signs to some extent[33]. Alois Riegl said that any religious symbol that fits artistically would eventually become a purely decorative pattern. Like the lotus pattern, when used as a pattern, it is more considered from the perspective of form, but people should not deny its symbolic value[34].

2.2.2.1 The relationship between patterns and social history

In ancient Chinese society, symbols depicting natural objects were constantly evolving, and in the process, people continued to enhance their visual appreciation. Symbols indicated the objective environment and social time. The pattern symbol was an image language, which expressed the information in the form of images. Therefore, the relationship between the pattern and the text is inseparable. It is an essential branch of the text symbol system. In the early days, the Chinese character symbol system mainly imitated nature objects and engraved the continuity of communication and the transmission of information in it. For example, in the Shang and Zhou dynasties, symbols reflected the order of society and the order of the universe. Any symbol is not given a fixed meaning all at once but is gradually clarified in the continuous accumulation of perception and experience. The appearance of a symbol must have related experiences before and produced in the process of social interaction. It is a process of fixing the continuity cognition on a symbol, the inner continuation. As in the Shang and Zhou dynasties, people used the symbols "〇" and "日" to represent the sun, which was related to the meaning of existence and experience. The original meaning of experience presupposes the direct relationship between current experience, past experience, and expected experience (Figure 2-9).

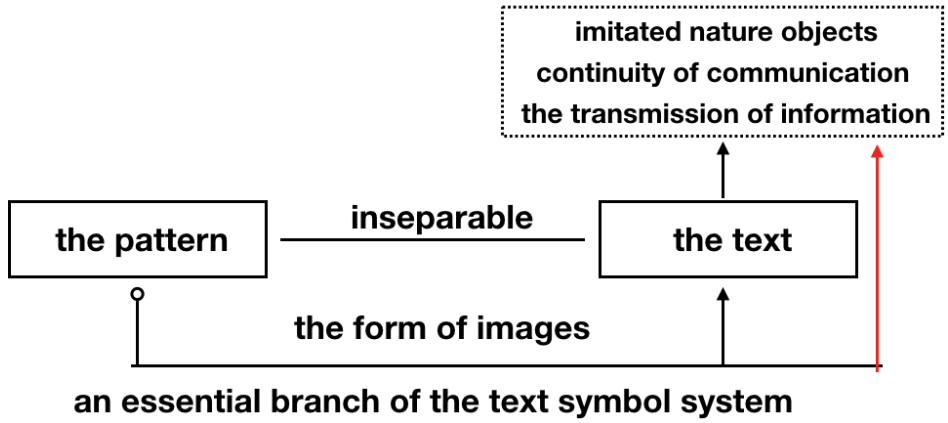


Figure 2-9 The relationship between patterns and social history

2.2.2.2 The relationship between patterns and social life

The Chinese symbol system is not formed in a vacuum; it is structured in social interaction. People could use words and pictograms to communicate at that time, indicating that there was already a meaning system that everyone was accustomed to in social life. It was similar to the collective consciousness structure of the group. The pattern symbol had a specific communication effect because, in addition to understanding its surface decoration meaning, it was more fundamental that it reflects the social meaning text structure that everyone has become accustomed to (Figure 4). It was the most essential time structure in daily life, like "time" "favors" or "generations", which would be condensed into some concrete symbols in a different aspect. In Chinese art, the most famous decorative pattern is the taotie pattern (Figure 6). It means "gluttonous" in Chinese. In modern Chinese literature," the meaning of 'taotie is not [about] "eating people" but making a mysterious communication between people and Heaven (gods)." It referred to a mythical ferocious creature that owns a head without a body, cannibalism before swallowing it, then perishes itself to illustrate the principle of retribution"[35]. Carl Hentze believes that the Chinese patterns of sacrificial vessels show a cosmic symbol of a "unified graphic scheme": gluttony symbolizes the earth, birds symbolize light, and reptiles represent the water world[36]. Art creation comes from life and feedbacks to life.

The picture shows an engraved spade jar from the Liangzhu period in Shanghu Village, Yuhang, Zhejiang. The circle of decorations on the jar, through the imagery of the ornamentation, some scenes of people's life activities at that time can be guessed, including figures of beasts, nets, and people. These patterns used slightly abstract symbolic language

to tell the story of the Liangzhu people going out hunting beasts at that time: People shot them with bows and arrows, trapped them with nets, and took them home.

2.2.2.3 The relationship between patterns and social change

To use the past to serve the present is to inherit and carry forward the unique style and characteristics of the nation. The selection of content and carrier should be appropriately optimized according to the current situation, rather than entirely referring to the old symbolic form. For example, due to lifestyles and differences in aesthetic appeal, it is meaningless to draw Bagua patterns on bronze mirrors on current artifacts. The content reflected by the pattern graphics is different, and the form changes accordingly. The things used by the ancients today are not what the ancients used back then. People explore pattern design (from the Neolithic Age or earlier) to form a unique order of patterns and transform natural features into concrete or abstract symbols in the pattern. This process must be handled by some graphics rules that have been produced, which meets the aesthetic needs of visual art at that time.

The development of Chinese patterns has been very slow. In 5000 years, it has experienced several foreign style influences; the most notable is the Tang Dynasty style. The establishment of the Silk Road brought Indian Persian and Eastern Roman pattern styles into China, injecting new vitality into traditional Chinese patterns, and cultivated a group of new pattern design talents, like Dou Shilun (a designer of silk patterns in the Tang Dynasty). He was good at absorbing foreign patterns like birds, horses, deer, sheep, and Lianzhu into Chinese patterns. The evolved patterns are called "Ling yang Gong patterns".

All kinds of Chinese and foreign products came together in the city of Chang'an in the Tang Dynasty, with unique decorations from various places. Such as medicinal plants called "Baicao" in the pattern (later named Small tufted flowers in Tang Dynasty) and the Sogdian Whirl pattern, which have never appeared in the Han Dynasty[37]. The patterns of sea beasts and grapes were only found in the Song Dynasty and have never been seen before. The combination of exoticism enriches the style of the pattern. In many cases, the occurrence and demise of things cannot be distorted and changed subjectively. People will become bored with the long-term familiarity of the visual laws. After the Song Dynasty, simple patterns appeared. During the Yuan Dynasty, Kublai's reforms changed the fragile literati style in the Song Dynasty. Chinese decorative patterns were dominated by the pure types of a few ethnic groups. Folk artists also absorbed some of the characteristics of ethnic minority patterns and

incorporated them into local patterns. Under the order and format of the Baoxiang pattern, the element was replaced by a peony flower with a more Han aesthetic preference. The plum, orchid, bamboo, and chrysanthemum were then extracted from the evolved unit form, thereby making the "small cluster flower" more meaningful. This kind of continuous adaptation to the evolution of the times enables traditional patterns to be rejuvenated and better inherited while partially retaining the old characteristics.

2.2.3 The semantics of the pattern

Ernst Cassirer believes that a symbol is a thing that can be marked by some self-evident or customary tradition or by a specific language's rules to mark something other than it. And pointed out that "all cultural forms are symbols."[38, 39]. Semantics is the study of the relationship between symbols and the objects they refer to.

Traditional Chinese patterns have unique visual morphological characteristics based on traditional aesthetics and carry some deep meanings: Most of the pottery patterns in the primitive period have symbols, forming the functions of instruction, reinforcement, and graphic decoration. A considerable part of them eventually became tribal signs and totems with symbolic meaning. The patterns of the "Four Gods" in the Han dynasty (202 BC–220 AD) have more specific symbolic meanings. After the Tang dynasty (618–907), although the patterns mainly were flowers and plants, they still had symbolic factors; The auspicious patterns of the Ming (1368 -1644) and Qing (1644-1912) dynasties are the development and deepening of the meaning of the pattern symbols and form a complete pattern semantics.

Chinese traditional patterns at a certain period showed the common understanding of the main groups, forming a conventional concept. As an ancient country with a long history of 5,000 years, Chinese traditional culture has been influenced and merged by various ideas to create unique regional characteristics. Just like Oriental culture, which is based on traditional Chinese culture, the performance of traditional art is the most distinctive. It often focuses on expressing the artistic conception and creator's accomplishment, emphasizing the significance of understanding and sublimation. The symbolic attributes of traditional Chinese patterns are from the object image to the extended meaning. The symbols of the pattern include things that exist in the objective world and things constructed for ideas: the objective existence needs to be transformed by common understanding, and the things constructed by views need to pass through the group by convention. In the long process of pattern development, patterns that combine objective and conception appear one after another. This mainly occurs in myths and legends, forming a combination of reality and fantasy, expressing people's longing feelings. This rich visual form and specific meaning constitute the semantic attributes of the pattern.

2.2.3.1 The signifier of Chinese traditional pattern

The development of Chinese traditional pattern

The leading carriers of traditional Chinese patterns are various utensils. It has been six or seven thousand years since the Yangshao culture (5000 BC-3000 BC) using patterns as decorations. It is obvious from the various artifacts left behind that the development process of patterns has a gradual and staged characteristic. The evolution of any pattern is the development, widening, and deepening of people's lives. It is also the process of human culture from low to high rank and from scarcity to enrichment. Changes in the living environment also bring about developing and improving pattern semantics, forming a relatively stable meaning.

The generalization of traditional Chinese patterns is mainly based on historical periods and subjects as the main division methods, but most of these two situations are intricately combined. The development of its themes can be divided into three basic theme patterns: geometric patterns, animal patterns, flowers, and grass patterns; comprehensive patterns: divine patterns, utensil patterns, human patterns, celestial patterns, text patterns, myths, legends, and historical stories. Most of the comprehensive theme patterns are changed from basic, but there are also many changes in the two. For example, the Chi (mythology) or bird shape in the cloud pattern of the Han Dynasty is a new pattern combining the cloud pattern with the animal pattern, which has a strong sense of movement. The general induction and sorting of traditional Chinese patterns incorporate utensils, materials, textures, and artistic expression styles and summarize the development of patterns from the perspective of life.

The patterns on painted pottery in the primitive age are in their infancy, and geometric figures are their main characteristics. Its emergence reflects the early totem consciousness expressed by primitive humans engaged in fishing and hunting activities. The two craft culture climaxes in this period has many typical representatives. The colored pottery culture is represented by Yangshao Culture and Majiayao Culture in the north; the jade ware is characterized by Liangzhu Culture in the south, which embodies the highest level of the arts, crafts, and development patterns of the primitive era. The primitive ancestors integrated the visual objects in life and the natural world into a rich pattern world according to their understanding and opened the source of pattern culture, including Cishan culture, Hemudu culture, Qujialing culture, Hongshan culture, and Datong culture, Wenkou culture, and Liangzhu culture .

The bronze patterns of Xia, Shang, and Zhou Dynasties showed the people's martial spirit in this period. Kui dragon pattern, Kui Phoenix pattern, and taotie patterns, etc. The patterns became stable and powerful because of the solid religious mystery and monarchy

consciousness. In the Spring and Autumn Period and the Warring States Period, the main patterns are bird and beast patterns and geometric patterns, which mainly represent real-life scenes, and the shape is flexible. In addition to bronzes, tiles, utensils, clothing, and architecture, the patterns used in the Qin and Han Dynasties have many rich patterns on the tomb bricks, murals, silk paintings, and screens. Animal prints and figure patterns are widely popular. During the Wei, Jin, Southern and Northern Dynasties, wars were frequent, and Buddhist patterns, especially Baoxiang patterns, were unprecedentedly popular, which injected new vitality into traditional Chinese patterns. During the Tang Dynasty, peonies became the mainstream decoration. The integration of Chinese and foreign cultures created a new era of traditional patterns; During the Song Dynasty, the patterns became more realistic and exquisite. The popularity of flower and bird paintings promoted the popularity of flower, bird, insect, and fish patterns; The patterns of the Yuan Dynasty have unrestrained and simple northern ethnic characteristics. Large-scale flowers and leaves, pairs of dragon and phoenix patterns, and fish-shaped patterns are more prominent. Minority culture and Han culture gradually merged; During the Ming and Qing Dynasties, the development of traditional Chinese patterns reached a peak. The patterns retain the characteristics of previous patterns and absorb a lot of foreign styles. Numerous subjects, lively and diverse styles, and a wide range of applications have profoundly impacted the social culture of later generations (Figure 2-10).

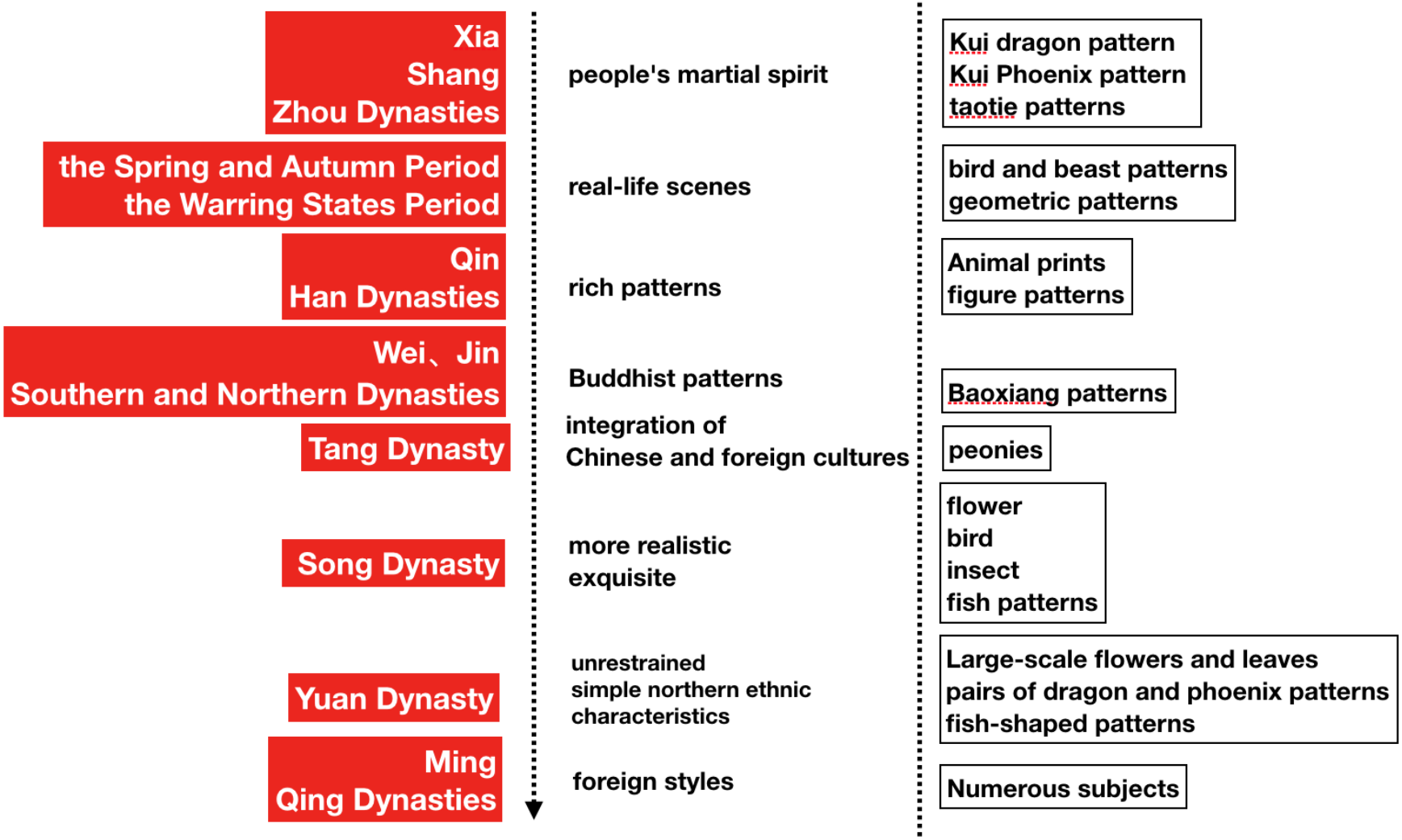


Figure 2-10 The character of traditional Chinese pattern

The style of Chinese traditional pattern

Traditional Chinese patterns have their styling development context, from the initial simple lines and single color to the current complex graphics, diverse structures, various contents, and rich colors. Starting from the patterns on painted pottery, with the improvement of material conditions and lifestyles, primarily based on satisfying basic survival needs. Patterns have become more prosperous and more extensive, covering production, life, religion, and sacrifice. They are primarily presented in individual and continuous patterns, characterized by showing their spiritual needs through the screening of actual production and life.

In the heyday of slavery society, the patterns on bronzes were rich and varied in subject matter and rigorous in structure, reflecting the exquisite craftsmanship of the time and reaching unprecedented heights. In the Spring and Autumn Period and Warring States Period, bronze ware and lacquer ware were typical representatives, and jade ware and weaving embroidery were also widely used. The patterns on the artifacts have changed from crude and straightforward to mature and refined, from being mysterious to civilians and vivid. Due to the limitation of production technology, bronze wares rarely have repeated shapes and generally only exist in a single piece. The high cost makes it a representative of aristocratic status, especially during the Spring and Autumn and Warring States period when the ritual system was prevalent. The use of bronze artifacts became a symbol of ruling authority. The resulting pattern has a solemn and inviolable authority.

At the beginning of feudal society, the Terracotta Warriors and Horses of Qin Shihuang Mausoleum and many pottery warriors, pottery horses, tiled ornaments, bronze mirrors, chariots, and portrait bricks showed the artistic characteristics of the times. With the rise of painting and the widespread of Buddhism, the lotus flower as a symbol of Buddhism has become one of the main themes in Buddhist art. In the progress of social civilization, pattern art is mainly manifested in ceramics and silk woven utensils, with a realistic style. The patterns of flowers and birds have smooth lines, simple graphics. They are elegant and beautiful. During the Ming and Qing Dynasties, auspicious patterns were the most popular, and symbolism reflected people's yearning for a better life.

From a simple visual effect, the pattern shape has undergone specific changes along with the social system. These changes reflect the fundamental idea that patterns are produced in and serve society. With the enrichment and advancement of technical conditions, the modeling becomes more detailed and fuller, and the semantics become more diverse,

penetrating all aspects of society. Its composition is delicate and full of flavor. The performance on the artifacts is more magnificent, can reflect the designer's wisdom, and reflect the spirit of the times. The manifestation of this characteristic is the fusion of the cognitive concept of the times and the pattern, and its surface form contains people's ideas and concepts (Figure 2-11).

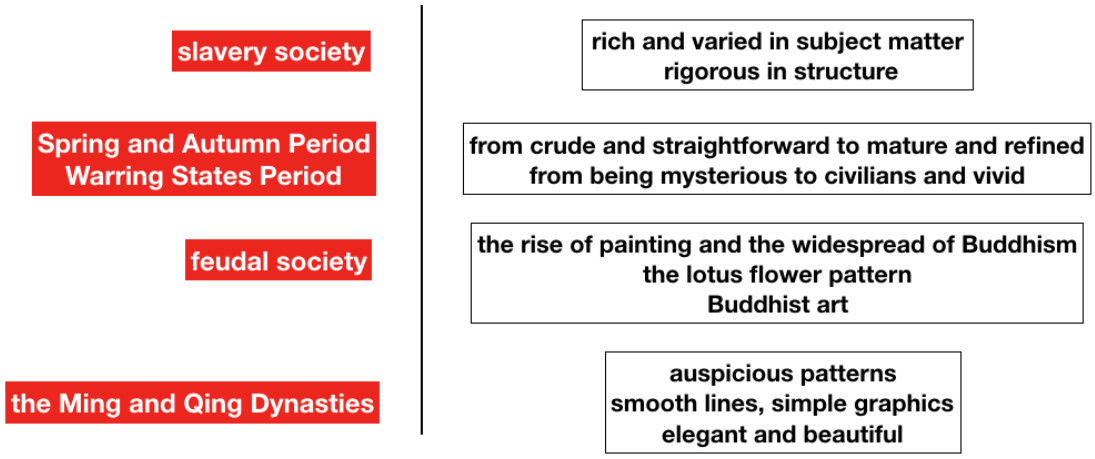


Figure 2-11 The style of Chinese traditional pattern

2.2.3.2 The signified of Chinese traditional pattern

The change and fusion of connotation

Chinese traditional culture is rich and long-lasting, from the graphic art of primitive society to the plastic art of late feudal society, from natural simplicity to exquisite beauty. Its manifestation and connotation are the symbolic meanings represented by its shapes. Still, they change from dynasty to dynasty, forming a symbol of the times, and are sought after by the people. The basis for its transformation is affected by objective reality. It is always in line with the local social customs, materials, techniques, and artistic skills. It often has distinctive characteristics of the times and regions. While forming the cognition of different times, the cultural difference of the regional population has become its main product. For example, the most representative dragon image in traditional patterns has been sought after by the ruling class throughout the ages, and many factors have restricted its formation and development (Table 2):

In the primitive period, the dragon pattern was simple, powerful, and with egalitarian colors. It was a simple expression of emotion. The shape was peaceful, harmonious, and

fantasy.

The dragon pattern on the bronzes of the Shang and Zhou dynasties was stern and solemn, representing the deterrence and coldness of the slave-owner class, and the possession and plunder of property by people under private ownership.

- In the Han and Wei dynasties, the dragon's patterns were elegant and flowing. At the same time as the end of slavery, people had more opportunities for self-expression and freedom of thought.
- The dragon's patterns in the Tang Dynasty were full and rich. Materiality and civilization had become the world leader, and the form of the dragon pattern contrasted with the society of the flourishing Tang Dynasty.
- In the Song Dynasty, the dragon pattern was solemn and regulated, while the social system at that time was becoming more and more perfect, and the spirit of the legal system was deeply rooted in the hearts of the people.
- During the Yuan Dynasty, the dragon's patterns were robust. With the ideological background of the grassland, the shaping of the bone shape was dynamic and aggressive.
- In the Ming and Qing Dynasties, the dragon pattern was gorgeous, reaching the peak of artistic expression in feudal society. The dragon pattern as the main image was combined with natural patterns such as waves and auspicious clouds to form a scene of flying, swimming, walking, and enjoying the wind and rain, gradually creating a sacred image.
- In the late Yuan Dynasty, the level of dragons was artificially distinguished from the number of dragon claws. The five-claw dragon was used exclusively by the emperor and other supreme rulers. After many generations of development, the dragon pattern finally became the origin of the feudal emperor's authority symbol.

This is the change of dragon patterns and other traditional Chinese patterns, such as water patterns, cloud patterns, and fish patterns. The morphological change is an extension and inheritance of the connotation of the pattern, a derivation and expansion of its external form.

The influence of foreign culture is also the driving force for the artistic innovation of the pattern. The colorful and ever-changing curled grass patterns in the Mogao Grottoes of Dunhuang were created based on the honeysuckle form introduced from the Western Regions during the Han and Wei Dynasties. The most typical pattern in the Tang Dynasty is based on the lotus flower as its original shape, combining the characteristics of the peony and pomegranate patterns, and gradually formed the national style pattern. These patterns

did not mechanically copy foreign art but integrated their meanings and gradually became part of traditional Chinese pattern modeling semantics.

The fusion of form and meaning

Without the influence of foreign culture, traditional Chinese patterns will not change much for an extended period. Because of its aesthetic form and deep meanings, graphic symbols are only the appearance of these connotations, the relationship between the symbol and the sign. Because of the persistent pursuit of "signified," the form can be passed down from generation to generation, and many branches have been derived. It can be said that the historical extension of "the signified" has given birth to the change of form. From a long-term perspective, they are also derived from each other. "The signified" and the form are mutually enriched and perfected, a unified dialectical thought.

The form changes in each period are often different from the previous period, but the form in each period has its unique style and artistic conception. From the elegant cloud patterns in the lacquerware to the flower and bird patterns in the porcelain, it is the highest pursuit of people's spiritual realm. After an extended period, it showed a fantastic vitality.

The design thinking of Chinese traditional pattern

Traditional Chinese patterns are art that combines static, dynamic, and both. Dynamic: give people a feeling of anger, relaxation, and pleasure; static: give people a feeling of dignity and calm; the combination of both: giving people a sense of harmony and perfection. At the same time, it is also the way of thinking that pursues balance and coordination in traditional Chinese thinking and a gentle attitude towards things.

The design thinking of traditional Chinese patterns has gradually matured. Its formation was mutually associated with Chinese traditional cultural thinking, and traditional culture was its source. The cultural, psychological structure constructed by history transmitted to the present society and impacted the cognitive psychology of users. Exploring its design thinking resources can provide benign ideas for the modern design field, and the formation of its thinking can represent the Chinese tradition, rather than simply copying the superficial style. The development of traditional Chinese patterns had a long history, during which it was influenced by multiple cultures and ethnic cultures, forming a magnificent pattern culture. During this period, ideas and thinking had constantly been changing, and many ideas played the critical roles.

- Systematic thinking： Adopt a systematic and holistic thinking mode for things, and do not look at certain things independently. While the environment was constantly changing, the things themselves were constantly changing. In this way, the things and the environment would form a good system. Given the different usage scenarios of the utensils, the shape and style of its patterns could play a good coordination effect with it.

  This kind of thinking also had another standard feature, which was good at establishing equivalence effects of things that do not seem logical and emotional relations. The connection between the shape and meaning of many things in traditional Chinese patterns was incredible for us, such as the graphic of toads. For modern people, toads have despised species under certain circumstances, but due to the massive number of ovulations, people used to associate it with the thriving population of descendants and grandchildren.

- Comprehensive thinking： All things and phenomena should be regarded as a whole. While promoting the advantages of things, they should also tolerate their shortcomings, think about the problem comprehensively, pay more attention to the background and relationship, and consider the strengths and weaknesses of things as two sides, which were complementary. With the help of experiences rather than abstract logic, artistic creativity will be more emotional. If you think that the whole world is made up of five essential elements, universal in reality. The properties of these five natural objects are also experienced and perceived by people in daily life. The "Five Elements" is not only the primary material for the formation of the universe. The so-called "the king used earth, gold, wood, water, and fire to form everything"[40], but also the basic order of the universe. "There are five elements of heaven, wood one, fire two, earth three, gold four, and water five. Wood, the beginning of the five elements; Water, the end of the five elements; Earth, among the five elements, is also the order of its heavenly rank."

  This mode of thinking also illustrates the opposite and symbiotic characteristics of things. For example, the Chinese Taichi pattern is a typical representative of the fact that they can only move in the opposite direction when things reach an extreme. From this, we can understand that most traditional patterns used aggressive, dangerous, ugly, and evil forms, such as fierce animals, legendary evil characters, and even fictitious images to resist demons and monsters. The purpose was to achieve peace and happiness. In the eyes of the ancients, ghosts were the representatives of cruelty and viciousness. They were things that can harm people. People also believed that other things also feared ghosts. Therefore, in traditional Chinese houses, they were often used as the image of a door god to ward off evil spirits. In temples and shrines, the gods revered by people

were usually glaring and fierce, some of them holding swords and sharp weapons. This is also reflected in the folklore of many parts of China. For example, in Shaanxi, people often embroidered highly poisonous animals on their bellybands, implying that the toxicity of these animals would resist the invasion of foreign evil in the future and protect the safety of children.

- Analogical thinking. It refers to thinking that compares and connects things based on the external characteristics or internal attributes of things. Traditional Chinese thinking is good at grasping specific correlations between things to carry out analogy and symbolism to achieve the purpose of analyzing and expressing from the near and far. Analogy thinking is an analogy between the external characteristics and internal attributes of "heaven, earth, human beings, and everything." Internal attributes such as "seeing the astronomical phenomenon then knowing human affairs."[41]. In traditional Chinese pattern design thinking, human beings were inseparable from nature and society. They had certain connections and contradictions. The ancients put them together for comparison, forming the ideological foundation and construction system of "the harmony between human and nature." Therefore, people pay special attention to the perfect embodiment of the pattern, forming a state of seeking fullness, richness, and abundance in the later stage.

2.3 Features of digital design

During the last twenty years emerging technologies have begun to influence central issues in design theory. Architectural design has become engaged with the exploration of complex geometries, 'free forms'[42, 43] as well as related materialization processes of fabrication and manufacturing technologies[44-46]. These developments have begun to exert significant influence on the theoretical, conceptual and methodological contents of design. These characteristics emerged in various designs that were realized before and after the millennium. In architecture, the Guggenheim Museum, Bilbao by Frank Gehry was the most prominent catalyst of theorizing new formal directions and postulating new design, materialization, and manufacturing methods. Beyond the post-modern sensibility of complexity through 'heterotopia', or complex hybrids, the Guggenheim, Walt Disney Concert Hall in Los Angeles, and other projects by Gehry introduced new geometric approaches freed from a priori formalisms, such as linguistic formalisms. Furthermore, the Gehry office was deeply committed to researching the potential role of digital technologies [47]. Praxis and theory evolved simultaneously. Innovative experimental precedents have emerged from design practice and academic design experimentation. Furthermore, recent works of Zaha Hadid presented in the Guggenheim Museum[48] are also demonstrating current 'evolving', heterogeneously para- metric themes that are preoccupying digital praxis today.

Before the application of digital technology, the means of architectural design were limited to the expression of two-dimensional space. This way of expression also limits the designer's imagination and design thinking. When digital technology is widely used in engineering design, materials chemistry, biology and other disciplines, people use cutting-edge technology to observe and construct nonlinear forms from a new perspective. The depth of the field of view is increased, the visibility is increased, and the convenience of operation is enhanced [49].

The application of digital technology tools has brought architects a liberation of thinking creation, freed from the shackles of two-dimensional thinking and turned to more open and free physical control. Let the in-depth expression of the design involve the whole process from the idea to the actual construction. In the field of architectural design, technology has profoundly affected the methods and ways of thinking of architectural design and has a significant impact on the form design of digital buildings[50].

2.3.1 Complexity of the shape

From 600 BC to 500 BC, the ancient Greek philosopher Pythagoras proposed that mathematics is the origin of all things and attempted to explain everything with mathematics. This promoted the development of the relationship between geometric forms and mathematics. "Beauty" has been pushed to the scientific level of philosophy. Vitruvius's "Ten Books on Architecture" also proposed "beauty" as one of the three elements of architecture and applied the natural geometric proportions of the human body to the architectural scale, summarizing the rules of architectural geometry. Based on the development of European geometry and related theories, the architecture presents the aesthetic meaning of symmetry and order. During the Renaissance, coordinate geometry proposed a research method to describe the relationship and properties of geometric objects using algebraic methods, which effectively promoted the development of navigation, astronomy, mechanics, and military at that time. In architecture, coordinate geometry has also promoted the subject application of architectural descriptive geometry. The expression mode based on plane, elevation, section and perspective drawing has gradually become the information means and standard for the expression of fixed architectural form. In the 19th century, Gauss, Lobachevsky, and Riemann developed non-Euclidean geometry. Non-Euclidean geometry greatly expands the connotation of geometry and brings the source of design to the trend of complexity.

The traditional European geometric theory has been unable to adapt to the development of digital architecture. Non-Euclidean geometry combined with computer technology also produced innovative architectural applications and influenced the aesthetic orientation of "shape". With the evolution of the complexity of the design order, pioneer architects are calling for new advanced geometry to deal with complexity. The rapid development of technology has made it possible to model complex shapes such as three-dimensional surfaces and achieve high-level geometric visualization. The advanced geometric concept of "shape" in architecture is an innovation of diversified and liberalized geometric forms brought about by the application of digital technology. In terms of architectural space, digital high-level geometry breaks the monotony and boringness of traditional spaces and activates horizontal and vertical spaces. The use of digital technology for geometric construction makes the space dynamic and changes, and the spatial sequence unfolds continuously and presents a temporal flow.

On the one hand, high-level geometry shows multidimensionality and anisotropy, with spatial uncertainty. The advanced geometry under digitization is interspersed and connected

to the original space system and forms a continuous nonlinear change, and finally forms a whole and contains multiple diversified spaces[51]. It is no longer a single-form space or a horizontal combination of multiple spaces in series and parallel but tends to be three-dimensional. The space enclosed by the structure is formed by the boundary of the structure. The simplest form of space is the geometry of "one body and six sides". It consists of two horizontal interfaces and four vertical interfaces, which constitute the most basic elements of the space. Advanced geometry opens the Pandora's box of structural space. The flexible and free structural form brings anisotropic structural space, and the parameter relationship of digital information makes the form variable and changeable.

On the other hand, advanced geometry breaks the traditional "horizontal" and "vertical" spatial patterns. Schulz pointed out that the lines of movement between two connected spaces in the structure are directional, bidirectional and dynamic[52]. When the space composed of two or more geometric shapes is put together, the connection between them is no longer indirect or non-flowing, but the space will open their respective interfaces. An organic connection is established between the horizontal system and the vertical system, intertwined and layered, forming a spatial relationship that merges with each other, and is continuously flowing and changing. Advanced geometry weakens and dissolves the traditional primary and secondary structure, decentralizes and de-bounds, thereby forming a free and flexible plane form. Cross and stagger the "horizontal" and "vertical" spaces, and through a certain degree of bending or topological deformation of the folded surface, a flow form with a soft boundary is formed. The user will feel free and open in the space of advanced geometry (Figure 2-12).

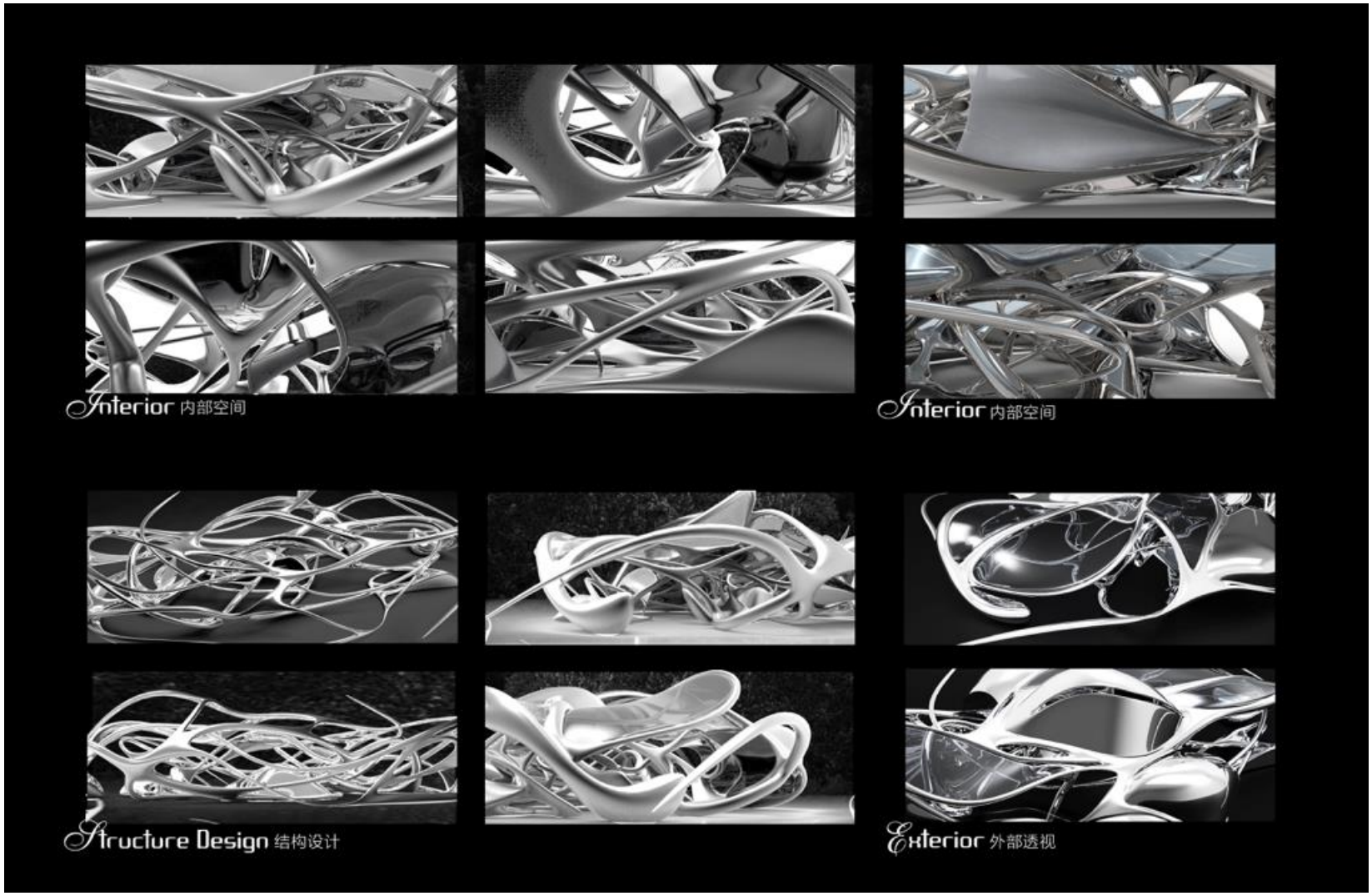


Figure 2-12 Complexity of the shape

2.3.2 Ecological of the form

Architects have been pursuing natural organic forms for a long time, and the ecological traceability of the structural concept deeply influences the form design. The "shape" of nature is complex and has an aesthetic significance recognized by the world. Chinese people often describe the "form" of nature as "completely natural" or "ingenious workmanship", which shows the high aesthetic value of natural "form" in the eyes of Chinese people. However, this natural "shape" is difficult to describe and simulate. It is ever-changing, with regularity hidden in it, attracting countless scholars to seek and explore. American designer Greg Lynn's "nomad city", "smoothness" and "dynamics" of digital design put forward by American designer Greg Lynn emphasizes the "self-generating" power of architectural design itself and responds to environmental influences[53]. Using digital technology, contemporary architects have the ability to grasp the diversified and dynamic simulation of the "form" of nature. For example，The first concrete pavilion in Europe developed by Lafarge Holcim and XtreeE. It is a one-piece coffee bean-shaped oval shape with an internal texture of the root texture; Joris Laarman designed the world's first 3D printed metal bridge in Amsterdam. The basic model is a tree-like fractal texture; the ICD/ITKE Research Pavilion is a segmented shell structure, imitating the complex internal structure of a sea urchin (Figure 2-13) (Figure 2-14).

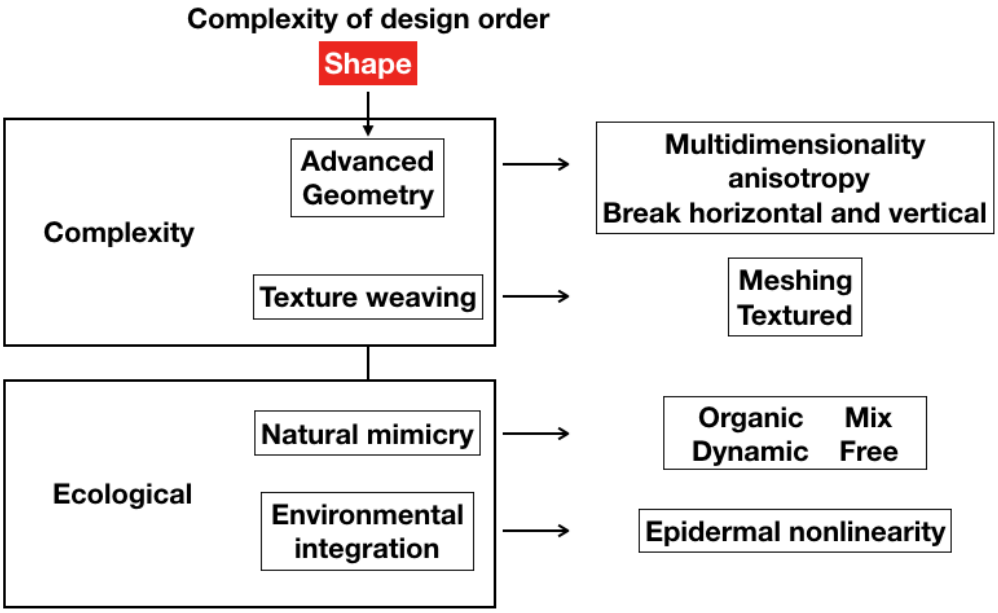


Figure 2-13 Combing the characteristics of architectural form

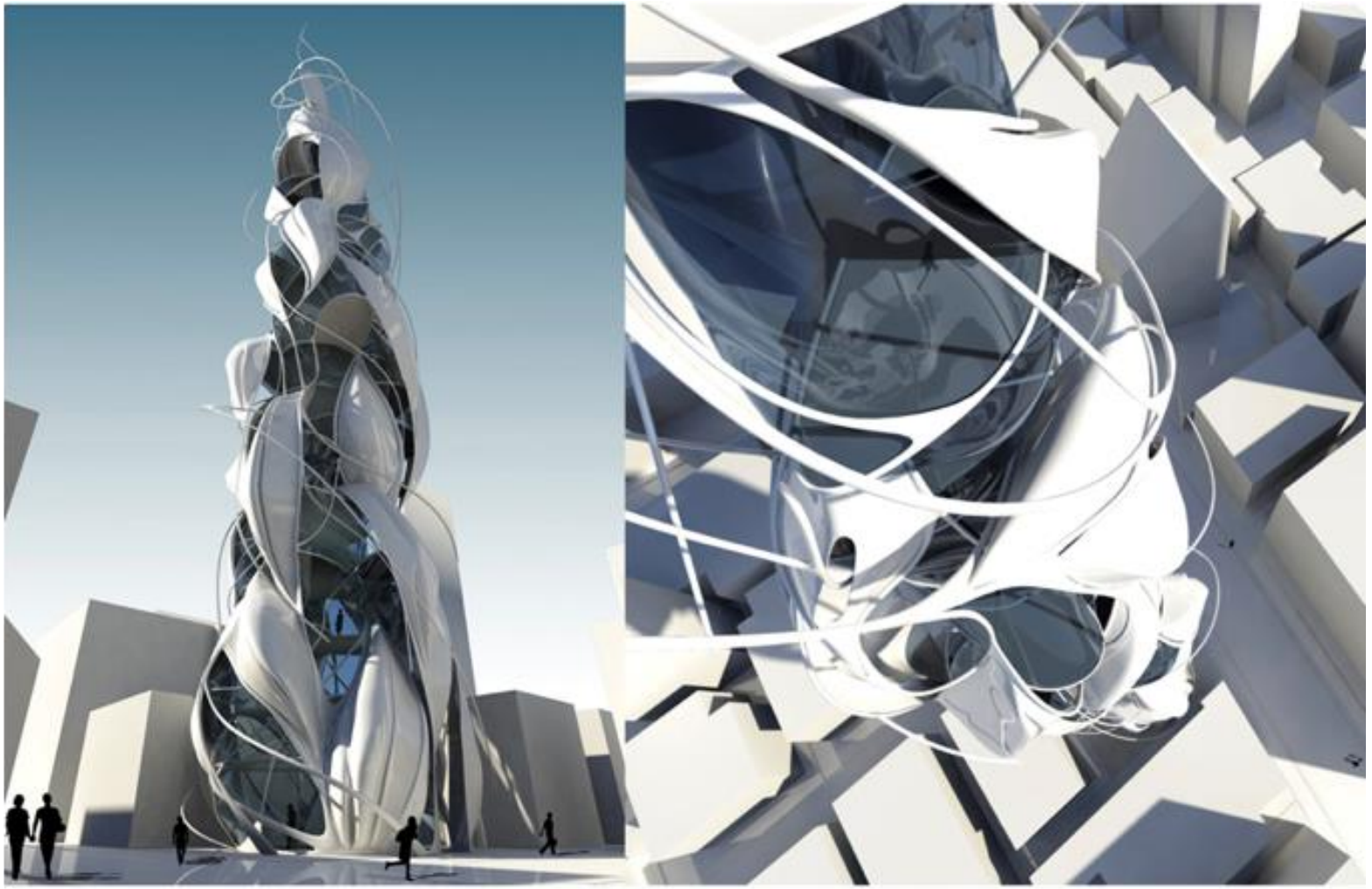


Figure 2-14 Ecological of the form

2.4 The popularity of digital design in China

The development of digital technology and computational modeling is changing traditional architecture design. From Frank Gehry to Zaha Hadid, they all expressed an evolution of architecture. It was an early digital practice. The concepts: topological form, spatial structure disorder, non-hierarchical organization, hyper-connective spatial conditions, etc. have appeared in the design world [44-46, 54]. The emerge of free form [42], other geometries [55], materialization processes of fabrication and manufacturing technologies affect the content of design theories and methodologies. The relationships between design and computation become a significant topic in design studies and practices. [56-58]. The integration of technology will bring new novel venues to design exploration [59]. Techniques and tools become true friends and partners of designers. High-techniques and software transform the process of design from make form-making to form-finding [60]. They are medias for the mind [61]. Designers could adapt, customize and reconfigure the behavior of the software 'to fit personal stylistic mode of thinking and working. Digital techniques change the traditional means of architectural works and help designers to study complex system behavior, including energy simulation and performance analysis as an integral component of the design process [62, 63]. "Human dominate mode" is not the single relationship between tools and architectures, but also machine dominate mode, balanced human-machine mode [64].

Under the influence of design computation and digital methods, the knowledge base of architectural design would be redefined [53, 65, 66]. Digital techniques had an impact on the development of architecture theoretical, computational and cognitive approaches as a foundation for design education and pedagogy. Various educators and researchers have tried to address the need to integrate digital design in architectural design education investigating various forms of pedagogical agenda (Shape grammars in education and practices: history and prospects [67-73] , which plays a fundamental role in guiding students to reframe their role in the future professional direction [74]. It is required to rethinking and redesigning better connection and relationship between teaching and learning in pedagogy [75].

In the 1980s, digital design media changed gradually, so does education [76-78]. Digital educational developments have emerged at Columbia, Harvard, MIT, Penn, UCLA, the AA, University of Applied Arts in Vienna, and elsewhere, which have been strongly motivated by

important digital practitioners as compared to the influence of a comprehensive educational curriculum [59]. Parametric Design and digital design have become a game-changer in design pedagogy and practice [79]. The increasing number and diversity of the digital tools enriches the course and results of the architectural design exploration process [64].

Reference

1. jie, K., Selections of Reference Materials on the General History of China / Edited by Shu Shizhen. Archeology, 1958(9): p. 102-105.
2. Longhua, Z., Reference Atlas of Ancient World History. 1960: People's education Press.
3. Plekhanov, Selected Works of Plekhanov Philosophy. 1974, Beijing: Life·Reading·Xinzhi Sanlian Bookstore.
4. Reference Atlas of Chinese Primitive Society. 1977, Shanghai: Shanghai People's Publishing House.
5. Zhimin, A., PROFESSOR PEI WENZHONG AND PREHISTORIC ARCHAEOLOGY IN CHINA: TO THE 90th ANNIVERSARY OF PROFESSOR PEI WENZHONG [J]. QUATERNARY SCIENCES, 1994. 4.
6. Wenzhong, P., Chinese Stone Age. 1963: China Youth Publishing House.
7. Museum, X.a.B., Neolithic site at Banpo near Xi'an. 1982: Cultural Relics Publishing House.
8. Zhang, X., X. Zhao, and L. Cheng, Human diets of Yangshao culture in the Central Plains. Chinese Archaeology, 2011. 11(1): p. 188-196.
9. CHINA, E.N.C.I.N., Early neolithic culture in north china. 2017.
10. Mingchuan, Z., Chinese Painted Pottery Atlas. 2005 Cultural Relics Publishing House.
11. Engels, F., Anti-Dühring. 2007: Duke University Press.
12. Chen-Xi, S., et al., The impact of middle to late Holocene environmental changes on human activities in the Qujialing region, Jingshan, Hubei Province. Earth Science Frontiers, 2009. 16(6): p. 120.
13. Cui, Y., et al., Early ceramic trade in Gansu and Qinghai regions, northwest China: A comparative elemental analysis on sherds of Majiayao culture, Yangshao culture and Qijia culture. Journal of Archaeological Science: Reports, 2015. 3: p. 65-72.
14. Jianye, H., "THE PAINTED POTTERY ROAD" AND EARLY SINO-WESTERN CULTURAL EXCHANGES. Anabasis: Studia Classica et Orientalia, 2012. 3: p. 25-42.
15. Wang, C., Inheritance and Innovation Research on the Art of Painted Pottery in Gansu Modern Tourism Culture Design. 2018.
16. Chang, K.-c., The archaeology of ancient China. 1986: Yale University Press.

17. Institute of Archaeology, C.A.o.S.S., Archaeological Discoveries and Research in New China. 1984: Cultural Relics Publishing House.

18. Man, W., ON THE CHARACTERISTICS OF THE PAINTED BIRD PATTERNS ON THE NEOLITHIC POTTERY [J]. China Ceramics, 2013. 3.

19. Melton, D., Pattern formation during animal development. Science, 1991. 252(5003): p. 234-241.

20. Museum, N., Excavation report of the two mausoleums of the Southern Tang Dynasty. 1957: Cultural Relics Publishing House.

21. Selections of Han Dynasty Paintings. 1955: Chaohua Fine Arts Publishing House.

22. Nansheng, W. and Z. Ying, Plant Landscape Creation of Flower Sea. Journal of Landscape Research, 2016. 8(5).

23. Ying, W., A National Flower's Symbolic Value During the Tang and Song Dynasties in China. Space and Culture, 2018. 21(1): p. 46-59.

24. Ling, Y., A new compendium of materia medica.(Pharmaceutical botany and China medicinal plants). 1995: Science Press.

25. Yongxiang, C., The Dancing Image Decorations of the Painted Pottery in the Primitive Era. Sculpture, 2009: p. 01.

26. Lee, Y.K., Yangshao, in Encyclopedia of Prehistory. 2001, Springer. p. 333-348.

27. Yan, K., The Artistic Features of the Banpo-style Painted Pottery in Yangshao Civilization. Journal of Yuncheng University, 2011.

28. Qing, L., The Research for the Conception Beauty on Graphical Chirography of Chinese Character. Art and Design, 2012.

29. Mao, G., Study on Cultural Connotation of Tattoo Custom in Women of Yi Ethnic Group in Liangshan. Journal of Contemporary Educational Research, 2019. 3(6).

30. Анферова, А., TATTOO AS AN ART FORM. Формирование гуманитарной среды в вузе: инновационные образовательные технологии. Компетентностный подход, 2013. 4: p. 206-207.

31. Hong-yu, L., Dance with Musical Accompaniment, Acrobatics and Games in the Han Dynasty. Journal of Minzu University of China (Philosophy and Social Sciences Edition), 2012.

32. Keightley, D.N., Sources of Shang history: The oracle-bone inscriptions of Bronze Age China. 1985: Univ of California Press.

33. Waring, J.B., Ceramic Art in Remote Ages: With Essays on the Symbols of the Circle, the Cross and Circle, the Circle and Ray Ornament, the Fylfot, and the Serpent, Showing Their Relation to the Primitive Forms of Solar and Nature Worship. 1874: London: JB Day.

34. Zerner, H., Alois Riegl: art, value, and historicism. Daedalus, 1976: p. 177-188.

35. Li, W.-y., The Idea of Authority in the Shih chi (Records of the Historian). Harvard Journal of Asiatic Studies, 1994. 54(2): p. 345-405.

36. Hentze, C., Chinese tomb figures: a study in the beliefs and folklore of ancient China. 1974: AMS Press.

37. Rawson, J., Inside out: creating the exotic within early Tang dynasty China in the seventh and eighth centuries. World Art, 2012. 2(1): p. 25-45.

38. Hamlin, C. and J.M. Krois, Symbolic forms and cultural studies: Ernst Cassirer's theory of culture. 2004: Yale University Press.

39. Skidelsky, E., Ernst Cassirer: The last philosopher of culture. 2011: Princeton University Press.

40. Qiuming, Z., Guoyu. Vol. 16. 2000: Art China.

41. Guanzhong, L., The romance of the Three Kingdoms. 2018: Penguin UK.

42. Zellner, P., Hybrid space: new forms in digital architecture. 1999: Thames & Hudson London.

43. Szalapaj, P., Contemporary architecture and the digital design process. 2014: Routledge.

44. Schodek, D., et al., Digital Design and Manufacturing: CAD/CAM Applications in Architecture and Design, 2004. Google Scholar.

45. Oxman, R., Theory and design in the first digital age. Design studies, 2006. 27(3): p. 229-265.

46. Bechthold, G. and S. Schodek, New Technologies in Architecture. Digital Design and Manufacturing Techniques: First International Conference, Harvard University Graduate School of Design, October 2000. Proceedings. 2001: Harvard University.

47. Lindsey, B. and F.O. Gehry, Digital Gehry. Englische Ausgabe.: Material Resistance Digital Construction. 2001: Springer Science & Business Media.

48. Mertins, D., P. Schumacher, and J. Giovannini, Zaha Hadid. Guggenheim Museum Publications. 2006.

49. Peterson, I., Fragments of Infinity: A Kaleidescope of Math and Art. 2001: Wiley.

50. Xu, W., Parametric design and algorithm generating. World Architecture, 2011. 6: p. 110-111.

51. Weixin, H. and X. Weiguo, " Form Finding" in Non-linear Architectural Design. Architectural Journal, 2009: p. 11.

52. Schulz, C.N., Existence, space & architecture. 1971: Studio Vista.

53. Lynn, G., Folds, Bodies and Blobs–Collected Essays. 1998.

54. Snyder, V., Refabricating Architecture: How Manufacturing Methodologies are Poised to Transform Building Construction. Journal of Architectural Education, 2005. 59(1): p.

51-52.

55. Rajchman, J. and C. Davidson, Constructions. 1998: MIT press.

56. Oxman, R.E., Precedents in design: a computational model for the organization of precedent knowledge. Design studies, 1994. 15(2): p. 141-157.

57. Oxman, R. and J.S. Gero, Using an expert system for design diagnosis and design synthesis. Expert Systems, 1987. 4(1): p. 4-14.

58. Oxman, R.E. and R.M. Oxman, Refinement and adaptation in design cognition. Design studies, 1992. 13(2): p. 117-134.

59. Oxman, R., Digital architecture as a challenge for design pedagogy: theory, knowledge, models and medium. Design studies, 2008. 29(2): p. 99-120.

60. Laiserin, J. Digital environments for early design: Form-making versus form-finding. in First International Conference on Critical Digital: What Matters (s). 2008.

61. Reas, C. and B. Fry, Processing: a programming handbook for visual designers and artists. 2007: Mit Press.

62. Shea, K., R. Aish, and M. Gourtovaia, Towards integrated performance-driven generative design tools. Automation in Construction, 2005. 14(2): p. 253-264.

63. Stouffs, R., et al. Geometric complexity and energy simulation. in Conference on Computer-Aided Architectural Design Research in Asia (CAADRIA 2013). 2013.

64. Zboinska, M.A., Influence of a hybrid digital toolset on the creative behaviors of designers in early-stage design. Journal of Computational Design and Engineering, 2019. 6(4): p. 675-692.

65. Lynn, G. and T. Kelly, Animate form. Vol. 1. 1999: Princeton Architectural Press New York.

66. Kwinter, S. and L.F.O. Architects, Phylogenesis: foa's ark; foreign office architects;[published in collaboration with the Institute of Contemporary Arts on the occasion of the exhibition" Foreign Office Architects: Breeding Architecture", London, 29 November 2003-29 February 2004]. 2003: Actar.

67. Knight, T., Shape grammars in education and practice: history and prospects. International Journal of Design Computing, 2000. 2(67).

68. Oxman, R., Educating the designerly thinker. design Studies, 1999. 20(2): p. 105-122.

69. Oxman, R., The mind in design: a conceptual framework for cognition in design education, in Design knowing and learning: Cognition in design education. 2001, Elsevier. p. 269-295.

70. Oxman, R., Think-maps: teaching design thinking in design education. Design studies, 2004. 25(1): p. 63-91.

71. Snoonian, D. and D. Cuff, Digital pedagogy: An essay. Architectural Record, 2001.

189(9): p. 200.

72. Knight, T. and G. Stiny, Classical and non-classical computation. Arq: architectural research quarterly, 2001. 5(4): p. 355-372.

73. Özkar, M., Learning by doing in the age of design computation, in Computer-Aided Architectural Design Futures (CAADFutures) 2007. 2007, Springer. p. 99-112.

74. Charalambous, N. and N. Christou, Re-adjusting the objectives of architectural education. Procedia-Social and Behavioral Sciences, 2016. 228: p. 375-382.

75. Garrison, D.R. and H. Kanuka, Blended learning: Uncovering its transformative potential in higher education. The internet and higher education, 2004. 7(2): p. 95-105.

76. Schon, D.A., The reflective practitioner: How professionals think in action. Vol. 5126. 1984: Basic books.

77. Schon, D.A. and G. Wiggins, Kinds of seeing and their functions in designing. Design studies, 1992. 13(2): p. 135-156.

78. Oxman, R. and R. Oxman, The computability of architectural knowledge. The Electronic Design Studio (The MIT Press, Cambridge, Mass., 1990), 1990: p. 171-185.

79. Holzer, D. BIM and Parametric Design as Game Changers, Rethinking Comprehensive Design: Speculative Counterculture. in Proceedings of the 19th International Conference on Computer-Aided Architectural Design Research in Asia, Kyoto (Japan). 2014.

Chapter 3 Research Methodology

3.1 Introduction

This chapter intends to clarify the approach to research taken within the thesis by elaborating on an architectural research methodology that is based on the objective of the thesis.

Through three fields study of graphic analysis studies, digital design experiments, and Quantitative analysis on teaching feedbacks, and online data analysis, a mixed-method research strategy is applied in this thesis.

Pattern research and digital design research are carried out layer by layer based on three methods, to the theme of the study, which is evolving around how we think and understand traditional things and architecture practice, it ought to be relevant to several aspects of the profession.

3.2 Methodology

To investigate this research question, the research methodology is designed. The word method has its origins in Greek and means to choose a path. In the following, this chosen path is discussed and described.

Architecture as an academic field is still in the midst of developing its own research tradition [1], so is the traditional art. In this vacuum, the challenge to researchers is to draw upon research traditions, methodology and philosophy of science from other fields while creating research relevant to architectural practitioners and traditional culture researchers. The research methodology used in this study is therefore composed of a number of research methods.

The lack of traditional research results in a great degree of freedom in the choice of methodology. Roughly, science can be understood as three separate traditions with each their philosophy of science, each their view of what relevant knowledge is, and each their methods of choice. Where natural sciences generally speaking deal with the actual, material world that can be measured, typically, social sciences are less interested in the actual, material world, focusing instead on how human beings perceive the world and interact with each other and the world according to said perception. The humanities in equally general terms are even less interested in the actual, material world but focus on understanding texts, art and other man-made objects.

A research project concerned with traditional culture and architecture design would focus on "reading" traditional through a modern understanding of architecture. This project, however, is not solely interested in traditional pattern redesign, but as a character of the digital architectural practice, therefore, this approach is supplemented with other research traditions.

3.2.1 Mixed method research strategy

The three fields of research questions are unfolded in parallel. But it is promoted layer by layer. As the theme of the study is evolving around how we think and understand architecture practice and traditional culture, the theme ought to be relevant to several

aspects of the profession. This is the basis for the tripartite approach to the subject, a structure that facilitates an engagement with three kinds of thinking.

The first question guiding to a deductive thinking: how can traditional patterns transport with times and the logic of form reflected? The second question points towards an application thinking: how to apply this thinking when creating? And the third approximates a pedagogical meta-thinking to disseminate: How to gain recognition and think accordingly? Following this principle, the study employs three different research methodologies following the three sub-questions. The purpose of mixing research methodologies is to establish a more nuanced understanding of the subject and increase the breadth of the inquiry. The aim is not to establish always applicable knowledge, but to explore a subject from different angles that would have appeared one-sided and in lack of nuances if approached from one method alone. A mixed-method strategy is believed to balance weak points as the methods will complement each other.

The project consists of three studies correlated with the three sub-research questions concerning the theory study, design experiment, and teaching. The structure of the methodologies is following an abductive mixed-method research strategy as shown in the illustration figure. On a conceptual level, the research design follows Charles Sanders Peirce's description of the reasoning in the methodology of science: "Its reasoning should not form a chain which is no stronger than its weakest link, but a cable whose fibers may be ever so slender, provided they are sufficiently numerous and intimately connected"[2]. In this manner, the study intends to engage comprehensive thinking about the traditional pattern development and digital design in three levels: to analyze, to apply, and to disseminate.

The project started from a critical wonder of the traditional pattern in advanced technology emerging within the architectural design workflow. First, establish a relationship between digital design and traditional pattern culture, and use pattern materials for digital design. The entire research must first understand the compositional elements and formation rules of the pattern. This law must be used throughout the entire research and used in the whole practical operation. The subject of digital experimental is then approached through two progressive studies, exploring an analytical deduction, a design experimental to apply. Then through a teaching questionnaire survey to verify the topic.

Repeatedly during the process, the attention is returned to the wonder, questioning whether the state of the argument provides new and satisfactory insights. As a consequence,

the three studies are interlinked and the course in one study will influence and inspire the progression of the two others resulting in the concluding argument becoming a synthesis of the whole study (Figure 3-1).

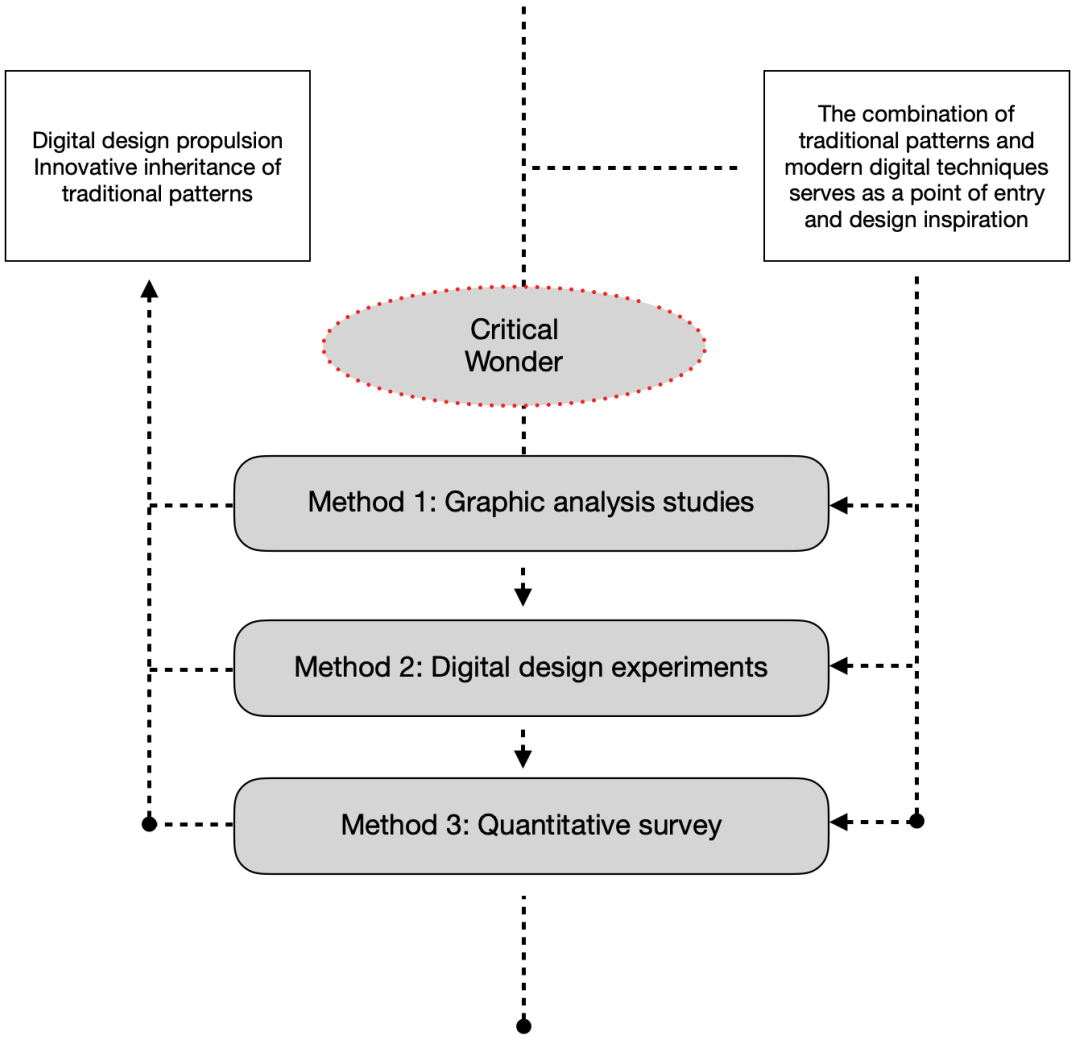


Figure 3-1. Model of the mixed-method research strategy applied in the study

Given the three kinds of thinking embedded within the research questions and the mixed-method research strategy, not one individual epistemology is able to span the study as a whole. The study thus seems to fall in-between three epistemological traditions, and an essential part of the project thus is to identify how they can be combined together for the credibility of the study at large. Each epistemological tradition is present in all parts of the study, but in different intensities. A rough distinction is that study I, the graphic analysis study, is leaning towards philosophical hermeneutics、art hermeneutics; study II, design experimentation, towards pragmatism; study III, the teaching questionnaire, towards empirical analysis. When that is said, as the three sub-studies are thematically linked,

developed in parallel, and building on each other's knowledge, a strict division between the three epistemologies, as with the studies in general, is inadequate and will not provide a sufficient framework for understanding the study.

3.2.2 The hypothesis of traditional pattern as design inspiration for digital design experiment

The design thinking study with regard to the definition, mechanism, and process of design creativity is still mysterious but nevertheless of central interest to the field of cognitive and digital design. Many studies attempt to understand the cognitive processes underlying the creative behavior of human designers and, as a consequence, discuss the ability of computers to mimic and enhance the designer's creativity. Recently, people have begun to realize that making variations of existing and stereotypic choices is the key to pursuing creativity [3]. On the one hand, expand the boundaries of knowledge acquisition. Change from different perspectives, including expanding the boundaries of expressing knowledge and obtaining various ways[4, 5]. The goal is to discover new problems rather than solve existing problems[6]. To create something, we didn't think of at the beginning of the project, we will start working in different ways, as we start from a novice, gradually become an expert, and then become a creator[7, 8]. On the other hand, creativity also belongs to the inter-relationship between personal and social-cultural levels of thinking[9]. Therefore, in addition to the creativity of design, knowing how to make changes in the field of knowledge within the social and cultural category is another important direction for solving creativity[10].

The keywords in the methods: Graphical (based on drawings and technical schemes), analytical (based on geometric) and design practice (based on measurements of actual shapes and geometries). This thesis tries to recognize the complexity and diversity of traditional patterns by geometric diagram method, extracts the hidden logic and individual representative elements from the intricate details as the basis of practice. A first requirement of the method is to read and understand their traditional visual language by means of drawings. The whole complex has to be decomposed to specific forms with limited variety and quantity. Designers convert text and graphic information into data information, refine and regenerate the traditional patterns, and then apply them to new design practices

The origin of creativity presented by modern design forms lies in the increasingly "flattened" world, as described by American scholar Thomas Friedman in his work: The world has entered a new era: version 3.0 of globalization. This version further reduced the world

from small to miniature and razed the arena to the ground. Software and the network not only make the world smaller, but also make the world flatter[11].

Digital technology has dismantled the invisible barriers between nations and people, enabling people to gradually exchange information and use the same standards to view the world from a global perspective. Almost all forms of expression: text, music, photos Images and sounds are all described by data. People have become accustomed to using bits and bytes to digitize content. The flat world has inspired designers' sources of inspiration, and data has become a bridging agent between technology, humanities, and art.

In the "flat" world, information and graphics are the materials that describe everything and are the driving force behind the interpretation of all information by human beings. People's understanding of the world has transitioned from empiricist perceptual cognition to epistemological rational analysis. This cognition It changed the designer's creative inspiration, and also affected the public's perception of beauty. The digitized world will become a global market that is not restricted by any national boundaries. Humanistic technology will become a force to disintegrate all feudal, religious, and national entities. Marx's "The Communist Manifesto" predictably interpreted this kind of society phenomenon form:

All fixed old relationships, as well as the concepts and insights that are compatible with them, have been revered, and all newly formed relationships become obsolete before they are fixed. All the fixed things have disappeared, and all the sacred things have been desecrated. People finally have to look at their status in life and their mutual relationship with a calm eye[12].

Technology bridges the barriers of cultural, language, and ideological differences, and changes people's understanding of the world. In the field of art design, science and technology have come to the end of divergence, humanities are dissolving science and technology, and humanistic technology has led designers to think about the origin of the modern world. Digital form has become a means for modern designers to express design ideas, making the world easier to communicate, and at the same time making art design more common. In the process of creativity, designers show national characteristics in different forms, and think about modern formal vocabulary with the concept of human community. Convert form, color, and structure into bits and bytes, and analyze and deconstruct the most indescribable aesthetics in the form of information.

The traditional motifs of Chinese are very intricate and luxurious with obvious signs of the times. And they did not lose the inheritance of national characteristics with the changing times. Chinese patterns also draw many advantages of foreign graphic designs. The designation of symbol patterns mainly includes two categories of abstract geometric figures (including various characters such as oracle bone inscriptions) and natural sceneries from the perspective of the theme. Shape and color constitute the structure of pattern language. The philosophical systems of aesthetics between China and the Western countries are slightly different, so it is not appropriate to directly quote the Western theory to understand the beauty of traditional Chinese motifs. In the Chinese lifestyle, although art and aesthetic activities have specific rules, they do not only focus on possible structures and forms. It is an expression of overall judgment in resonance with nature. As Cai Yuanpei said: "Chinese painting, based on calligraphy, has the interest of literature; Western painting, related to architecture sculpture, has the scientific observation and philosophical thinking. Therefore, Chinese painting, better with its vigor and rhythm, a painter is also good at writing and poems. Western painting, better with skill and connotation, those who are good at painting also are skillful in architecture and drawing. And the development of art is accompanied by the development of technology " [13]. The digital sculpturism model produces extremely complex decorative details. They are impossible to achieve by traditional software like AutoCAD, Sketch-Up, and ArchiCAD. Drawing analysis and Maya software are the primary tools to do this experiment design practice.

The changes in the means of creation in the design field brought about by digitization have resulted in a large number of design forms. The impact of digitalization on mankind is reflected in the following two specific directions: On the one hand, it improves the efficiency of human life and work, frees man from complex mechanical labor, so that mankind has more time and energy to develop more creative work[14]; On the other hand, digital technology can help human beings turn wild imaginations into reality, simulate and realize many fantastic images and forms. The digitization of forms is the final result of digitization. People's analysis and extraction of information must rely on the means of data decoding. The beauty of order embodies the essence of the information behind digitization. Because of these large amounts of digitized information, the design form presents a logical mathematical beauty.

The digital design form must be realized by digital technology. In the specific operation process, the designer must master the actual operating software while exerting his creativity. These software are drawing tools that can provide powerful data calculation and storage functions, such as 3D MAX, MAYA, RHINO, SketchUp, Photoshop, Illustrator, Corel Draw, etc., they can assist the designer to design and conceive on the computer intuitively. The designer

uses this software to model and continuously modify, increase and decrease details, and the final model formed can be Debug and render directly in the software, and realize it through 3D printing technology or multimedia technology. The special design form comes from the designer's extraordinary creativity, but at the same time the designer also needs powerful operating software to assist in the realization of specific creative ideas. The realization method using computer analysis as a tool also counteracted the designer's creativity to a certain extent and gave birth to the diversification of design forms. The design form that appears in modern design is the result of the development of digital technology, which is the projection of quantifiable information and the real world in the virtual space. Digital technology provides a technical basis for design schemes with digital aesthetics.

In the traditional pattern practice the second step is how to apply digital technology to the protection, interpretation, and recreation of art and cultural heritage. Reconstruct a new structure with the extracted elements by Autodesk Maya, Rhino and Pixologic Zbrush. Maya and Rhino are two commonly used modeling software for free-form shape, which respectively represent Nurbs surfaces and Polygon surfaces. Rhino modeling process is based on the geometry logic. The form is not limited by accuracy, complexity, order, or size. Maya software is mainly used in the film and animation field; in the design attempt, the model not only integrated the polygonal subdivision modeling technology but also combined dynamic, animation and deformation tools to generate complex structures. The specialty is that it provides a powerful polygon network modeling method, the target shape can be continuously subdivided, and the operation of different subdivision levels is essentially a geometric definition process of topology.

It is a process of topology changes and parameter changes. Besides, Maya is a modeling software with a physics engine. Due to the operation of point clouds and particle systems, physical factors can be introduced in the process of geometric construction, thereby responding to the temporality in the physical environment. Compared with Rhino, Maya can be considered as software for temporal transformation in geometric parameterization. The project practice uses Rhino and Maya software to simulate traditional pattern illustrations, use the data relationships in the study, establish physical models, and adjust parameters as needed to provide data models for digital construction. Zbrush is a digital sculpting and painting software, widely used in the computer graphics industry to assist Maya software.

The original intention of the software collaboration is to express the natural and sophisticated geometrical form of the building to the fullest. It will enable the patterns

reconstructed away from the formation generated by the optimal algorithm. The essential elements can continue the Baroque aesthetic—the ultimate and luxurious aesthetic forms as far as possible. The design mainly emphasizes the sculpture style objects in the way of performance, finally ends with additive manufacturing in different scale models. Repeat the extracted essential elements by "Extrude" and "Subdivision" two mainly commands. Use transformation, simulation, mutation superposition and other methods to diversify and reorganize the elements. The entire shape, structure and texture are all based on this. From bottom to top, from inside to outside, the accumulation method evolves a sense of hierarchy, ensuring visual extensibility and volume permeability. The form of sculpture can go beyond the basic structure. As a result of manual control, the process will not automatically generate by software that sets up formulas or specific algorithms, but carefully refine and sculpt specific shapes by hand. Digital sculpture advocates an ecosystem based on the human scale. Demonstrative form organizations put individualism above the standard, digital sculpturism is loyal to its original situation, and harmoniously unifies the subject and object to make it visible. This open-minded thinking is a new way for traditional design. Designers can give full play to their potential in the production of the shapes and inspire individuals to express their desires at the maximum and the highest level in sculptural beauty — an attempt to form an extraordinary, aesthetic approach led by personal artistic concepts and visual effects. The "sculpturism" digital design methods and concepts took shape during this process.

Multimedia technology has opened up a larger display domain for diversified design forms. The design form not only stays in the plane field and physical form, but also reflects in the virtual form and the visual illusion formed by sound, light and electricity. The leap of visual form is closely related to the development of multimedia technology. Driven by multimedia technology, the design form is no longer a plane figure in a two-dimensional space, or a three-dimensional shape with buildings, sculptures, packaging, etc. as entities. The final exhibition space is no longer a flat carrier with paper media as the core, or a touchable form that actually exists. The multimedia display space based on the digital platform transforms the design form from "real" to "virtual". The high-definition picture quality seamlessly connects the virtual and the reality and presents a more refined and rich design form through digital encoding and decoding. The level of human perception of arbitrary shapes can be easily obtained through the display screen of any mobile terminal. Therefore, multimedia technology has created basic conditions for new forms of design and display, and at the same time, it has also brought an upgrade of audience perception and experience perspective (Figure 3-2).

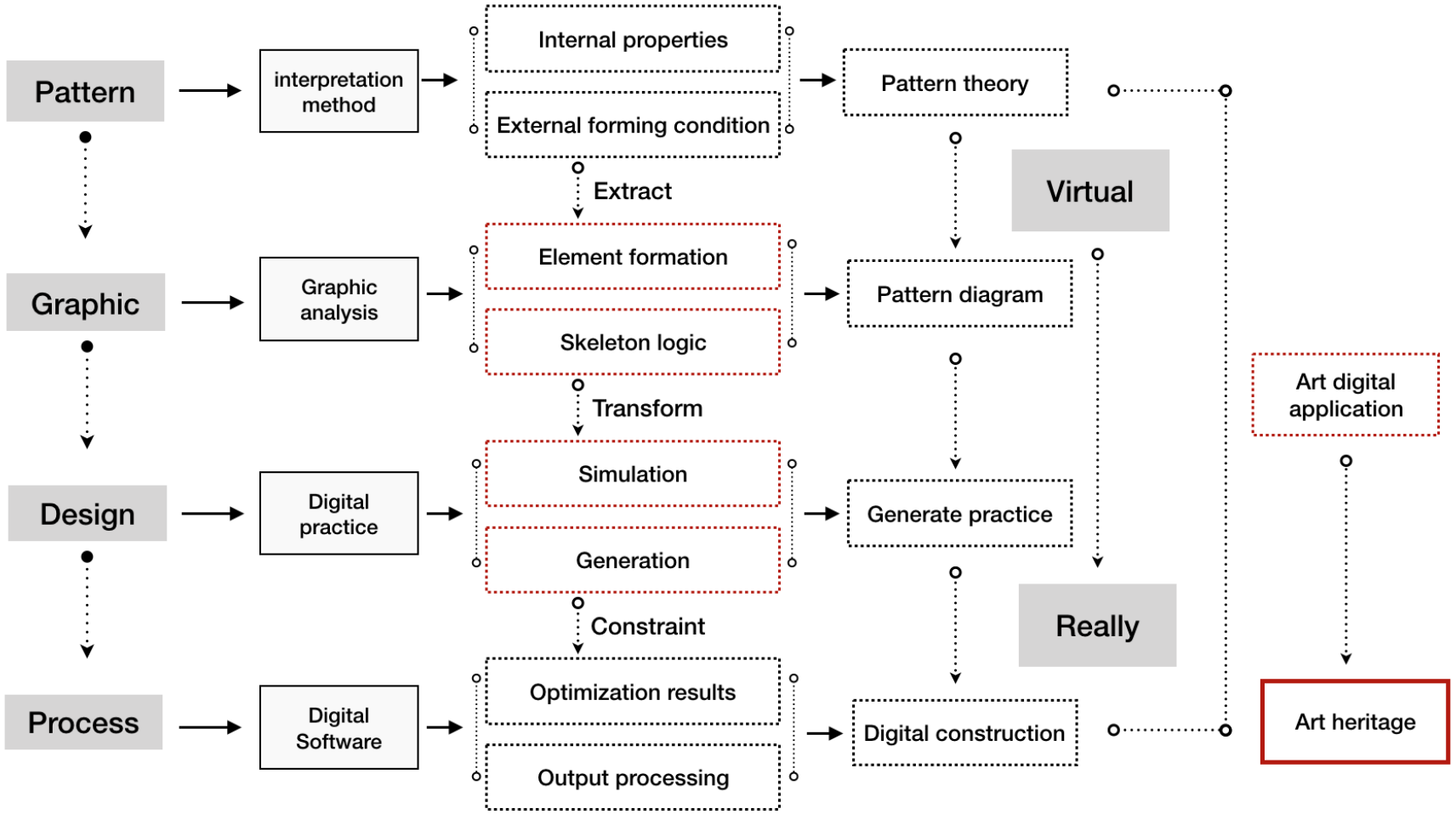


Figure 3-2 Model of traditional pattern applied in the digital software

3.2.3 Questionnaires survey

The questionnaire research mainly includes two aspects: The first is the basic situation and background investigation of the participants before the combination of digital technology and traditional patterns, and the other is the investigation of their impact after learning. Data research is used to evaluate whether the combination of tradition and modernity can better carry on the inheritance of traditional patterns and whether it can promote architectural design education.

The first aspect: Before experimental：basic understanding and necessity research before specific operations.

By analyzing and comparing the collected data, we try to see whether the lower grade students are suitable for using digital software and technology, and whether the modern architecture education curriculum configuration meets the needs of the market and professional development.

For architects, they need a wide range of knowledge accumulation to cope with the design work, and as the most important are the auxiliary design tools. The mastery of architectural software is very important. The data statistic is held to study the contemporary national architecture profession needs. The main aim of the study is to bridge the gap between computer software pedagogy and the profession requirements. The paper seeks to reach that objective through identifying the recent digital software approved in the architectural profession, providing an insight into the recent digital technique's trends turning up in the architectural profession fields.

The survey data comes from the latest recruitment information on Gooood's website for the 2020-2021 year employing, a total of 316 design firms of all different sizes in China. These include 145 Yangtze River Valley design companies, 71 South China design companies, and 100 North China design companies (Some firms have branches in different regions). Among them, more than 50% of the architecture studios located in Beijing, Shanghai, and Shenzhen, where the most desired places for architecture graduates in China. The rest are located in various regions of China. According to the recruitment position information they have provided, after sorting out the software requirements that designers need to master, including traditional 2D and 3D design tools, digital techniques like Rhino and Grasshopper, Maya graphics processing software photoshop, illustrator, etc., the statistical results are

obtained.

Three main analyses examine the use of contemporary digital software and techniques in the design industry:

- The first analysis is the role of computer applications in the architecture, science and research fields, namely: interior and exterior architectural design, urban planning, landscape design. Computer applications in the design industry can solve the problems better and more conveniently and has an important role in the field of architecture.
- The second analysis is the requirements for architects in different recruitment needs, especially traditional modeling software and digital modeling software. Analyze the difference between the two kinds of modeling software.
- The third analysis explores new trends and technologies in the field of architecture. Deeper analysis in different regions, the aim is to explore the new trends in computer applications in university pedagogy.
- Therefore, the utilization and requirements of the computer applications and digital software are studied and analyzed, the output of the survey seeks to help to form an efficient curriculum structure for digital techniques and software in architectural pedagogy.

From an academic point of view，there has been an increasing amount of incorporation of digital design tools in the thinking and making in the architectural profession. New formal and structural geometries by digital techniques become more and more prevalent. Back to the pedagogy, digital tools start to emerge in the design courses as key components of general curricula and teaching in particular. But educators and researchers held different ideas, there is no consensus in the education community on whether digital applications should be used in early architecture education. Different regions and schools have their own teaching programs. This study focuses on students' personal experiences and feelings in learning and using digital software through a questionnaire survey. The questionnaire was carried anonymously through online, web, and mobile applications to get more truthful and reliable feedback.

At present, architecture education in most Chinese universities is a five-year program. The elementary stage in the questionnaire means the first two years: Freshman year, Sophomore year, without a full study of architectural theory and methods (Use "1-2Y" in the following figures instead). Development stage students are junior and senior college students

(Use "3-4Y" in the following figures instead), and mastery stage students refer to college students in the fifth year, that is, the final year of undergraduate students (Use "5Y" in the following figures instead).

The basic curricular structures and approaches for the elementary stage students emphasize hand drawing, sketching and physical models, especially the first year. The foundational program aims at establishing a sense of construction and space. Digital software enters the curriculum program in different ways, some are independent courses and some along with design courses. The time of entry is also different. Some universities arrange their courses at the elementary stage, hoping that digital skills can be mastered as basic skills at the beginning of design learning; Some are in higher grades, and they hope students to cultivate mature design thinking first before using digital tools, rather than pursuing non-linear forms from an early age. Some do not cover these contents at all, and students' study by themselves based on their interests.

The first aspect is held to study the views and learning of digital software by architecture students in China. The digital modeling software in the questionnaire refers to Rhino, Grasshopper, Maya and 3D max, etc. This software is better at doing parametric design, non-linear design, more diverse and more powerful.

The second aspect: After participation: influence on participants, including traditional culture and digital design

The questionnaire data is used to study the participants' understanding of traditional culture and traditional patterns before participation, their understanding of traditional patterns after participation, and possible future attention. And the actual operation experience of digital technology during the participation process, including the degree of difficulty, degree of integration, and possible direction of the exhibition.

The questionnaire consists of two parts. The first part is to ask all the interviewees about basic information. A total of 10 questions includes the background information of the interview, the usability of the software, when to start learning, why and how to learn the technology, as well as the basic experience and feedback of self-study software use. Including when the interviewee used the digital software, at which stage of the design process, how it feels to use it, its advantages and disadvantages, and the greatest difficulty. This part of the question can have multiple answers or fill in according to your own situation. The second part of the questionnaire consists of 12 questions, including graded assessment, single-choice

questions and multiple-choice questions. It is aimed at some participants among all the interviewees, studying their participation experience and the difficulty of the course in detail. As well as the later impact on academic and professional; in terms of traditional patterns, they also consulted their early understanding of traditional cultural patterns, and whether they were more interested in traditional patterns after participating. It will receive more attention in the future.

In the questionnaire question setting, the questions about digital software and traditional patterns set at different stages, and the specific data research adopts the calculation method of descriptive-analytic. Quantify performance within the appropriate range of options. In the quantitative analysis process, effective statistical analysis methods were used, including Cronbach's alpha.

Cronbach's alpha

Cronbach's alpha developed by Lee Cronbach in 1951. It is a convenient test used to estimate the reliability, or internal consistency, of a composite score. Theoretically, Cronbach's alpha results are between 0 and 1.0. The general rule of thumb is that a Cronbach's alpha of 0.7 and above is good, 0.8 and above is better, and 0.9 and above is best. The formula is as follows:

$$\alpha = \frac{n}{n-1}\left(1 - \frac{\sum_{i=1}^{n} {S_i}^2}{S^2}\right); \quad S^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})}{n}$$

where:

N = the number of test samples. Si^2= the i-th sample variance. S^2= the total variance. x_i= value of i-th sample. $\bar{x}$= the mean value of samples.

The present descriptive-analytic and quantitative research were conducted based on the information collected through questionnaires and from existing quantitative records. The collected data were analyzed by SPSS.

The present descriptive-analytic and quantitative research were conducted based on the information collected through questionnaires and from existing quantitative records. The collected data of questionnaires were processed and analyzed by SPSS (version 26, IBM, Armonk, NY, USA) and Excel (Microsoft 365).

3.3 The conclusion of methodology

Architecture is often described as the intersection of art and science. Culture is the product of material and spirit, and spirit includes education, science, literature, and art. These two distinct realms, however, cannot be set in opposition; they should be cooperatively utilized in the creation of the built environment. Architecture is a creative art. The scope of this art is not narrow art. All technical products, even the art itself, are called art. There is no strict distinction between art and craft, and even science is also art. "The task of architecture is to process the external inorganic nature so that it can form a flesh-and-blood relationship with the soul and become an external world that conforms to art.[15]" The study of architectural forms helps to clarify the partnership between artistic concepts and artistic techniques in the process of creating architecture. Cultivate a broad knowledge and technical background so that the field that designers are engaged in has broken through the traditional category.

The pattern has many definitions, but they all tend to focus on those graphic elements. It seeks the relationship between pattern expression and the formation of logic. This application framework has the potential to be of value to students of architecture and researchers of traditional culture. It has the ability to help novice practitioners begin to understand and develop connections between design and culture.

In addition, this taxonomy of ideas provides an excellent way to study the world around us. By using a digital lens to study great works of traditional culture、traditional patterns, students have the potential to draw from these case studies critical lessons about the practice of architecture that will serve them for the rest of their education and as they move out into the professional world.

Reference

1. Mo, L., Philosophy of science for architects. 2003: Kolofon.
2. Peirce, C.S., Some consequences of four incapacities. The Journal of Speculative Philosophy, 1868. 2(3): p. 140-157.
3. Hofstadter, D.R., Metamagical themas: Questing for the essence of mind and pattern. 2008: Basic books.
4. Gero, J.S., Creativity, emergence and evolution in design. Knowledge-Based Systems, 1996. 9(7): p. 435-448.
5. Sosa, R. and J.S. Gero, Diffusion of creative design: Gatekeeping effects. International Journal of Architectural Computing, 2004. 2(4): p. 517-531.

6. Simon, H.A., Creativity and motivation: A response to Csikszentmihalyi. 1988.

7. Gardner, H., 12 Creative lives and creative works: a synthetic scientific approach. The nature of creativity: Contemporary psychological perspectives, 1988: p. 298.

8. Liu, Y., Creativity or novelty? A model of design creativity and its implications to computer. Design Studies, 2000. 21(3): p. 261-276.

9. Csikszentmihalyi, M., Society, culture, and person: A systems view of creativity, in The systems model of creativity. 2014, Springer. p. 47-61.

10. Liu, Y.-T. and C.-K. Lim, New tectonics: a preliminary framework involving classic and digital thinking. Design studies, 2006. 27(3): p. 267-307.

11. Friedman, T.L., The world is flat: A brief history of the twenty-first century. 2005: Macmillan.

12. Marx, K. and F. Engels, The communist manifesto. 1848. Trans. Samuel Moore. London: Penguin, 1967. 15.

13. Yuanpei, C., Chinese people's self-cultivation. CAIYUANPEIMEIXUEWENXUAN, 1983. 63.

14. Floridi, L., Philosophy of computing and information. UK: Blackwell, 2004.

15. Hegel, G.W.F., Aesthetics Lectures on Fine Art: Volume 1. 1998.

Chapter 4 Analysis and Research on traditional Chinese pattern order

4.1 Introduction

This chapter focuses on the analysis of pattern graphics and its role in traditional Chinese pattern classification and skeleton structure, reveals the logic of the composition of traditional Chinese patterns, and triggers the initial steps of the entire design.

This chapter introduces the characteristics and analysis methods of pattern graphics, and then extends it to the composition methods of traditional Chinese patterns, including individual patterns, continuous patterns, etc. The compositional characteristics of Chinese traditional patterns are influenced by Chinese philosophical thoughts and contain unique meanings of elements. Traditional patterns of skeletons also have Chinese characteristics, including Taiji skeletons and Jiugongge skeletons. All of these provide the theoretical basis and graphic logic for the later operation experiment.

4.2 The analysis method of pattern order

4.2.1 Visual cognition

In the study of patterns, we must first understand visual cognition. Human recognition is not always conscious. We can perceive the eyes but not the shape of the eyes. The shape of the eye and its position is not the same thing. We can feel the direction of other people's sight, and we can quickly peek into the eyes of our companions. The spatial direction of the control action is also instinctive, but it is obvious. The sense of direction includes the perception of various order relationships, such as near and far, high and low, connection and separation, and the front and back belonging to the time category. So, in order to understand visual art, studying the perception of order is an inevitable part. The structure of the human eye concentrates the visual focus in a minimal interval. The biological structure of the body determines this result. When people want to look at a wider area, they have to expand the scope of their eyes. If many information symbols appear in front of people's eyes suddenly, the focus of vision will be scattered, and people will not know where to look. These visual elements have a traction effect on the movement of the eyes. The line of sight cannot find a fixed point, so there is no peace. A very organized person can quickly eliminate this uneasy effect. For example, there are 12 circles and 12 crosses in the figure (Figure 4-1). As long as they are organized according to specific rules, the confusion will disappear immediately. Gestalt psychology also emphasizes the perception of order. A neat arrangement has more continuations and fewer interruptions or fewer visually significant points.

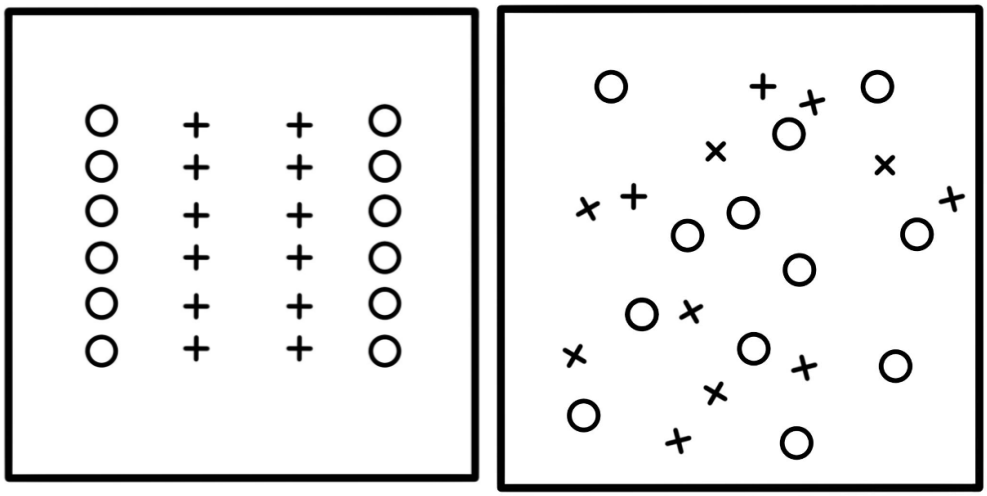


Figure 4-1 The focus of vision and its change

Rudolf Arnheim put forward the concept of "interruption" in "art and visual perception". He pointed out: In visual observation, the order will affect the visual experience. "In a coherent and smooth state, the observer is unlikely to see the well-known number 4 in figure spontaneously (Figure 4-2). In such cases, camouflage is obtained by putting old connections out of action and introducing new ones, changing angles into crossings, and manipulating correspondences, structural axes, and symmetries. Even an overdose of experience cannot counteract such tricks. To be sure, squares and rectangles are just as familiar as hexagons and fours. What matters is which the given configuration favors structures."[1] His view is correct. But there is no obvious interruption point. How can people distinguish "4"? People do not check whether they contain other lines when viewing the graphics. This is contrary to the observation method. The eyes cannot see the graphics in the same way. The eyes are habitually in a jumping state when browsing information, and the eyes will be attracted by the points that contain much information. They have equalized each unit's information in extremely regular graphics, so we feel more energy-consuming when observing disturbing graphics. It is more necessary to understand some people's visual viewing inertia to capture logic from seemingly chaotic pattern graphics.

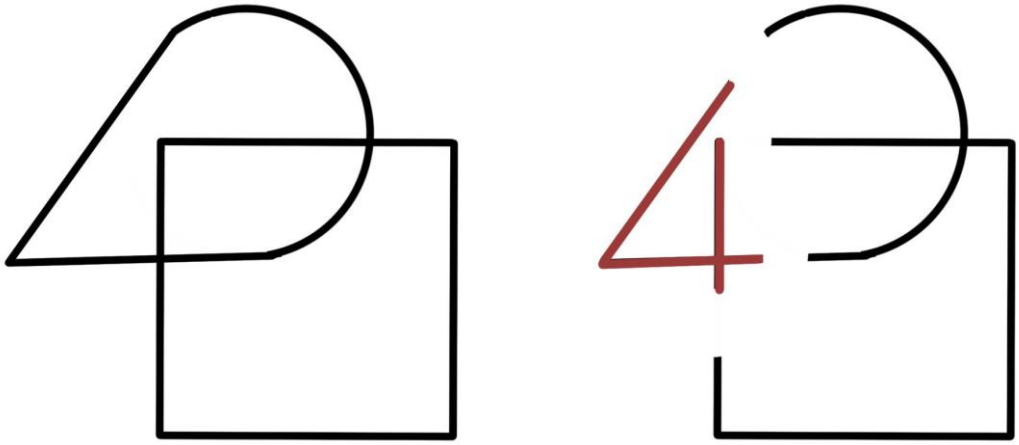


Figure 4-2 The concept of "interruption"

4.2.2 Mathematical thinking

Mathematical thinking logic includes geometric figure logic and strategy logic. Since people perceive that the formation of various crystals is composed of regular structures, scientists have studied the inherent possibilities of regular solid geometric structures and symmetrical arrangements. Mathematician Andreas Speiser used this idea to study the

geometric laws of pattern making [2]. To a certain extent, people who do not understand mathematics can understand his analysis. He used some of the most basic geometric drawing methods like compasses and rulers. For example, divide a circle into six equal parts with a compass and draw a rose pattern with a circle overlapping in part of the area (Figure 4-3). The stars, flowers, and wheels on the Phoenician ivory products and the Assyrian sidewalks were drawn using similar geometric mathematical methods. When making graphics, there is no limit to the subdivision of the circle. Although not all graphics are made the same way, grids are often used to aid design development. The feature of the grid is that it can extend infinitely in all directions. After filling in the specific composition components into each graphic unit, you can study the translation and rotation methods to obtain various symmetry relationships.

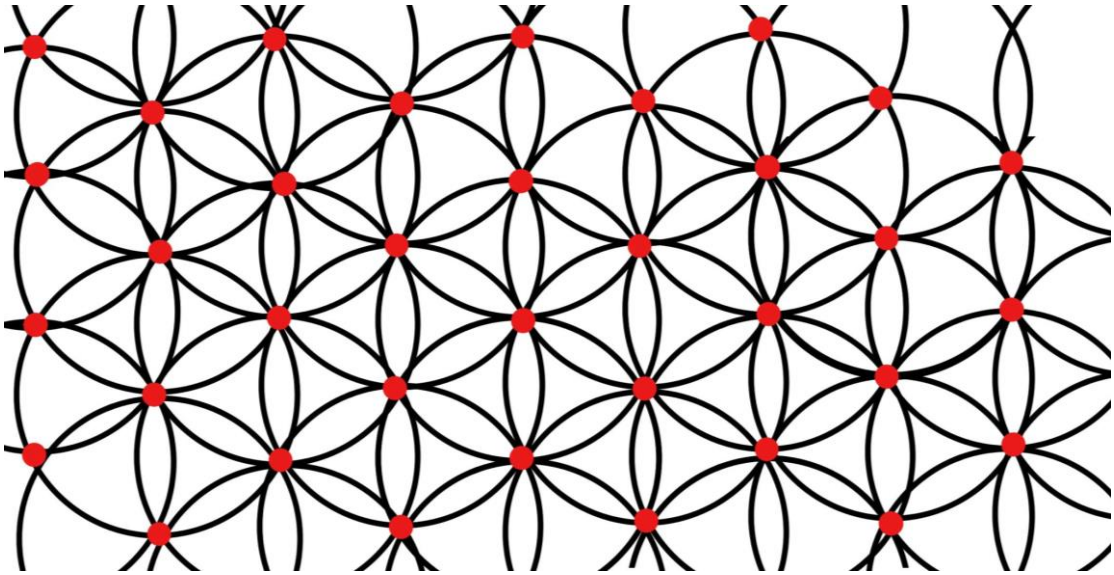


Figure 4-3 A circle into six equal parts with a compass and draw a rose pattern

These possibilities can also be obtained through mathematical calculations. For example, starting from an asymmetric basic graphic unit, extending a symmetrical graphic pattern, there are a total of many possibilities. This result can be verified by changing the axis coordinates. Of course, some people think that too much mathematical intervention may make pattern designers smarter in the process of designing. We should not confuse geometric symmetry analysis with mathematical permutations and combinations. As described by Speiser, designers can form countless patterns through various permutations and combinations with other graphics and methods. The intervention of mathematical thinking should not be seen as an imposed restriction, more like a catalyst.

Sebastien Truchet's "Methode Pour Faire Une Infinite de Desseins Differens Avec Des

Carreaux Mi-Partis" shows the connection between the formation of patterns and the laws of mathematical reproduction[3]. As shown in the figure, assuming that each square is an independent constituent molecule, divide the square into two halves along the diagonal and fill in two colors. When rotating these two-colour squares, four different graphics can be produced, which are marked with 1,2,3,4. Organizing two such squares in different combinations and arrangements can produce sixteen possible graphics. The symbols on the table are the interpretation of these combinations.

According to logical analogy, three squares can be cut and organized to produce sixty-four graphical possibilities. If four are used, there are a total of 256 graphical possibilities. By analogy, the result of the combination is an infinite number (ad infinitum). There are some pictures and tables in the book that illustrate the combinations of 72 systems. The first combination letter of the figure has been replaced. This replacement system is similar to the current method of using the "double helix" to represent the arrangement of the genetic code. The features of this code analysis can be unlimited.

4.2.3 Graphical analysis of pattern order

4.2.3.1 Circular graphics

In some handicraft decorations, it embodies the characteristics of "diversity" rather than repetition. That is, various patterns from simple themes are required to be supported by mathematical foundations. Use geometric terms to analyze a complex composition. This is an empirical analysis method that classifies lattice patterns based on the components. For example, in "power of form" by Robert William Billings , more than one hundred designs are in the book, all based on a simple diagram of coordinate axes[4, 5]. Put multiple circles in a large circle. The schemas expanded from this logic are diverse and exciting； Josef Albers is a figurative artist with a strong theoretical tendency. In his "despite straight lines" series design, he uses the simplest and most essential ingredients to change a variety of diverse and excellent rich arrangements.

4.2.3.2 Braiding weaving graphic

Celtic knots are various knots and stylized graphical representations of knots used for decoration used extensively in the Celtic style of Insular art. These knots are most known for their adaptation in the ornamentation of Christian monuments and manuscripts, such as the 8th-century St. Teilo Gospels, the Book of Kells and the Lindisfarne Gospels. Most are endless

knots, and many are varieties of basket weave knots. George Bain's "Celtic Art: The Methods of Construction" describes using mathematical analysis to re-understand the Celtic knot as a vital representative of traditional British culture[6, 7]. As a mathematician, George studied the weaving laws of Celtic knots. The celtic decoration is an abstract and non-imitative original artwork derived from the Celtic tribe in 500 BC. One of its signs is that a twisted rope weaves it in an alternating up and down weaving method, similar to an intertwined loop. There are similar artworks in many cultures, but George Bain and his son wanted to capture the mathematical patterns of knots. They selected patterns that appeared in manuscripts from the 7th to the 9th century. During that period, Celtic art was in a state of heyday. Celtic art is very complicated; the manual design is tedious and time-consuming and often requires practice to be brilliant. Many designs are difficult to change because changes in local details will affect the overall effect. Bain's skill is a tool that can quickly and easily design similar artworks. Humans use computer technology to add color to the design, which can save time for hand-designed decorations. It can also allow users to try to make partial or overall changes in style and form. Compared with similar hand-made artworks, automatic production of such knots in jewelry or decoration can save much time. When Bain studied how to redesign his "simple Celtic knitting pattern" with mathematical thinking, he explained the complexity of the knitting pattern as follows: numbers with no common factor produce an endless line when used with half-sizes at the four corners[6]. For example, top and bottom, four and two halves; sides, three and two halves. He simplifies the graphics for beginners with graphical explanations of mathematical geometry. There are certain restrictive conditions involved in complex designs, and the order of transportation cannot be dealt with pure abstract thinking. The analysis of such interweaving patterns requires the assistance of geometric calculations. Furthermore, there is no doubt that a mathematician uses a purely mathematical method to analyze the format of these complicated graphics, which requires extreme tolerance, and other knowledge is needed in addition to this. However, it is not too difficult to optimize and modify the traditional graphics simply by simplifying and adding decorations.

Knot theory is an area of mathematics that deals with the definition, structure, equivalence and minimization of knots. Scharein[8] implemented a program for the display and manipulation of such knots. The basic algorithm for artists as presented by Mercat [9] for creating a Celtic knot is conceptually straightforward, and we generalize it for our purposes: Following algorithm produces a complete three-dimensional Celtic knot. When viewed from above, the result can be displayed in two dimensions. Figure shows an example of this process (Figure 4-4): Define a planar graph; Find the midpoint of each edge. Put crossings at each midpoint; Compute the threads that compose the knot by connecting the

crossings; Inflate the threads; Calculate the overlap order of the threads and offset their height values based on the overlap order.

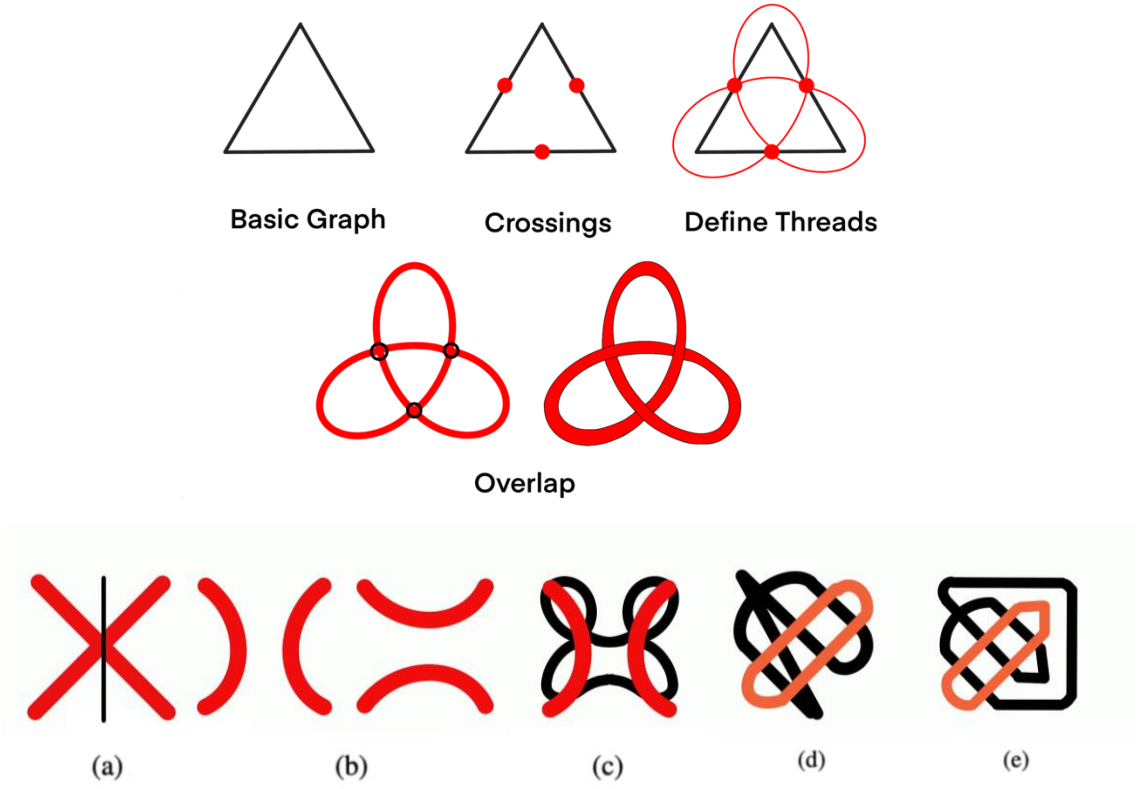


Figure 4-4 Scharein a Celtic knot

4.2.3.3 Fractal art graphic

Fractal art is a form of algorithmic art created by calculating fractal objects and representing the calculation results as still digital images, animations, and media. Fractal art developed from the mid-1980s onwards[10]. It is a genre of computer art and digital art which are part of new media art. The mathematical beauty of fractals lies at the intersection of generative art and computer art. They combine to produce a type of abstract art. Fractal art (especially in the western world) is rarely drawn or painted by hand. It is usually created indirectly with the assistance of fractal-generating software, iterating through three phases: setting parameters of appropriate fractal software; executing the possibly lengthy calculation; and evaluating the product. In some cases, other graphics programs are used to further modify the images produced. This is called post-processing. Non-fractal imagery may also be integrated into the artwork. The Julia set and Mandelbrot sets can be considered as icons

of fractal art[11]. Benoit Mandelbrot, the founder of fractal science, first mentioned the influence of fractal mathematics on graphic design in "Fractals: Form, Chance and Dimension"[12]. In his later "The Fractal Geometry of Nature"[13], he also expressed the close connection between graphics and mathematics, especially in the process of reciprocating graphic elements to form more complex graphics. For example, the reproduction of two-sided continuous graphics is more closely related to the sine waveform in mathematics. Its dimensions are not complete geometric figures but continuous self-repetition on increasingly subtle scales. This is a science that studies randomness and irregularity. The original purpose of fractal geometry mathematics was to find a more scientific way to re-analyze and simulate the more complicated and complicated figures in nature. Because fractal patterns appear similar in all scales, it is very suitable for dealing with infinitely complex graphics. Things like fractals in nature include clouds, mountains, lightning, coastlines, snowflakes, plant roots, various vegetables (such as broccoli), and animal skins. These irregular natural forms can be better imitated by combining numerous geometric components with the aid of mathematical formulas. Clouds, mountains, and coastlines are not objecting with extremely regular shapes, and bold generalization will reduce the interest and vitality of the graphics. The Latin translation of fractal is "Frangere", which means irregular fragments, both of which have the meaning of being split into smaller units. The figure shows the re-evolution of the sequence of numbers obtained from the natural extraction in the artificial state. Although the shape of graphics is full of commonality with natural objects, with the aid of artificial science, the beauty of graphics combined with primary unit bodies is even more mysterious.

4.3 The symbolic character of pattern

The Chinese symbol system likes an organism, enriching its inner vitality through close contact with nature. Through the imagination of natural objects and the presentation of situations, it expresses social and human thinking. The balance of the system can convey more meaning. For example, the meaning expressed by the Japanese pattern or the Chinese pattern is much richer than the orderly and straightforward geometric patterns of a single form of decorative function. People can always discover new things from it. This is a situation where explicit semantics and implicit semantics are perfectly coordinated.

Formal beauty exists in natural life and art, and patterns combine formal beauty and content beauty. The composition order, color structure, and symbolic modelling of patterns are the concrete carriers of the form beauty of the patterns, and the formal beauty of the patterns dramatically depends on its executive order. The order created by humankind comes from the beauty of form in nature, and everything in nature has its unique formal laws. The composition of the pattern has some fundamental orders, as follows:

- Symmetry and balance – Completeness

The pattern requires absolute beauty. This complete beauty is reflected in the pyramids of ancient Egypt, the temples of ancient Greece, and the palaces and temples of ancient China. These patterns have the characteristics of uniformity, symmetry and balance in form, which conform to the rhythmic aesthetic of "flowers and moons".

- Strengthen and weaken – Rhythm

The image of the natural world is in a more complicated form. When creating patterns, the characteristics of the graphics are more prominent by grasping the rhythm of strength and weakness. For example, the plum blossoms and bamboo leaves familiar in Chinese, blue-dyed printed fabrics, designers have strengthened their forms, reduced the number of appearances to make them regular, and highlighted the patterns' characteristics. Moreover, the facial makeup and costumes of Chinese Peking Opera use exaggerated rhythm techniques to upgrade the breath of life to artistic style.

- Change and Unity – Hierarchical

One of the traditional decorative patterns of traditional Chinese porcelain in the Han

Dynasty, "Xi Xiang Feng", the form of it is a pair of phoenixes, and two bunches of flowers, one positive and one negative, are united in a community. Derived from the "facing yang and against yin; The interaction between yin and yang creates a state of harmony." in the Tai Chi picture, one yin and one yang chasing each other, reflecting the dynamics of lively joy. The different and dissimilar elements of light and darkness, big and small, square, and circle, can be unified through a particular order. For example, the various types of glass sheets in the kaleidoscope produce various patterns under the concentration of the triangular mirror.

- Proportion and balance – Logic

Any pattern has a proportional relationship and mathematical relationship. Since ancient times, Chinese people have used odd ratios of one, three, five, seven, and nine. Such as fret pattern, moiré, "Ruyi" pattern, swastika pattern, eight-knot pattern, etc., all of which contain the beauty of the gradual arithmetic progression.

4.4 Classification of Chinese traditional patterns

Chinese traditional patterns can be divided into three types: Individual style, continuous style, appropriate style.

4.4.1 Individual style

The characteristic of individual pattern

1. Symmetric

Absolute symmetry: The symmetry axis or symmetry point of the patterns has the same shape and color, isometric organization, with an exact, calm, severe, and stable style, a strong sense of power. According to the different angles of symmetry, there are generally three forms: Left-right symmetry, up-down symmetry, reverse symmetry. According to the fundamental organizational dynamics, they can be divided into independent, relative, opposite, cross, centripetal, centrifugal, and combined forms.

Relative symmetry: The overall outline of the pattern is symmetrical, but there are some slightly different parts in shape or quantity with a combination freshness of dynamic and static.

2. Balanced

The balanced type is not limited by the symmetry axis or the symmetry point but free structure and stable center of gravity. The motif of the pattern is prominent, interspersed freely. The style is flexible and changeable. The sense of movement is strong. It can be divided into vortex form, S form, relative type, opposite type, cross-type, polyline type, overlapping type, and comprehensive type.

The development of individual patterns

From a historical point of view, the individual patterns of the Neolithic Age are rarely used on pottery, and they are more commonly used on jade and dental bones. Generally, do the main pattern. The composition forms include symmetrical, balanced, regular, irregular, upright and rotating patterns, with individual patterns composed of fish, birds, and beasts, and more balanced and irregular patterns. The individual patterns composed of animal face, human face, frog shape and geometric shape are mostly symmetrical and regular. Among the individual patterns, the swirl is the most diverse, vivid and unique. On the Qujialing

cultural colored pottery spinning wheel and the Majiayao cultural colored pottery[14, 15], there are more than a dozen styles such as two-sided symmetry, three-sided symmetry, four-sided symmetry, multi-sided symmetry and balance.

The individual patterns in Shang, Zhou, and Spring and Autumn periods are generally the main pattern, and the composition of the skeleton and order is diverse. The shape includes circle, square, triangle, semicircle, rectangle and irregular shape, among which circle and rectangle are more common. There are symmetrical and balanced ones, and symmetrical ones are more commonly used. Symmetrical forms include left-right symmetry, diagonal symmetry, three-sided symmetry, four-sided symmetry, and multi-sided symmetry. Among them, left and right pairs are called multiple. There are many types of suitable shapes, such as radiation, wave shape, and spiral shape.

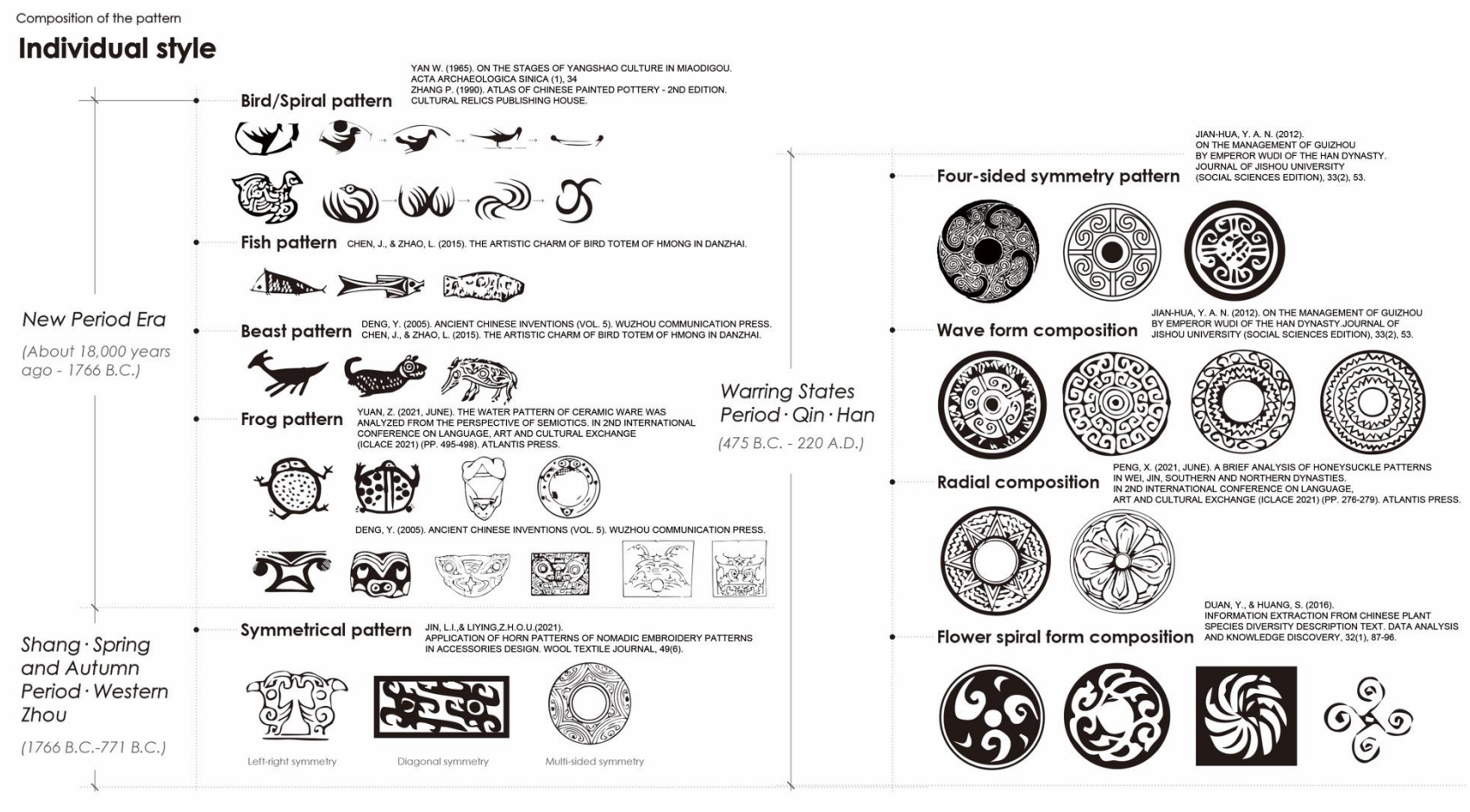
The individual patterns on bronze mirrors, tiled ware, lacquerware, pottery and jadeware during the Warring States, Qin and Han Dynasties were mostly regular and symmetrical, and a few were of balanced composition. The individual patterns on the portrait bricks and stone portraits are mostly balanced and a few are symmetrical. This difference is mainly related to their respective uses and production characteristics. In this period, the shapes of individual patterns were mostly square, round, semicircle and rectangle. Other forms are rare. In the form of composition, the geometric content is multi-symmetrical, and the animal theme is multi-balanced. There are two-sided, three-sided, four-sided symmetrical and multi-sided symmetrical forms in the symmetrical shape. The four-sided symmetry pattern on the bronze mirror and the Han Dynasty tile is the most distinctive and the most common. At the same time, this form is the most practical and the easiest to organize. These four-sided symmetrical forms are generally geometrical content. Its skeleton organization is mostly divided by cross or diagonal lines, and the same unit pattern is filled in four equal divisions. In the Han Dynasty, many tiles in the Han Dynasty used the "G" shape as the basic shape to be changed, forming different forms of tetrahedral symmetrical patterns. The Wadang patterns[16] of the Han Dynasty were developed on the basis of the similar cloud patterns of the Wadang in the Warring States. The composition of the Han Dynasty is more diverse and complete than that of the Warring States. Most of the forms of balance are composed of animals. In the arrangement of the composition, the weights are high and low, the virtual and the reality, especially the force's reference, the combination is natural, and it is quite original. The shape is more rectangular, and there are also round, square and other polygonal shapes. There are many suitable forms, such as wave form, radial form, spin form and irregular form. Most of the composition is symmetrical form, and the balanced form is rare. There is double, triple,

quadruple and multiple wave lines. Radiation styles are mostly telecentric, but heart-seeking styles are rare. Spiral patterns often used three-element combination and four-element combination as the basic shape on Warring States vessels. This kind of composition was rare in the Qin and Han dynasties. There are anti-rotation and three-sided, four-sided, and five-sided rotation in various forms. Waveform, radial and spiral patterns are suitable for individual patterns. The shape is usually round, and most of them are used as cover decorations. Individual patterns were generally used as main patterns in the Warring States, Qin and Han Dynasties, and were used more extensively than in the Shang Dynasty, Western Zhou, and Spring and Autumn Periods.

The individual patterns of the Sui and Tang dynasties were used as the main pattern in all aspects. There were still more regular and symmetrical forms, and the balanced forms were also more common. Dunhuang patterns, stone and brick carvings, bronze mirrors and ceramics were often used. Among the symmetrical forms, there are usually two-sided symmetrical shapes, and there are also three-sided, four-sided, five-sided and six-sided symmetrical forms. The content is mostly flowers, birds and beasts, and characters are rare. There are two forms of round and square shapes, and other forms are rare. The content of the balance form is mostly animals, followed by plants, and other content is less common. Among them, the composition of tangled branches is the most distinctive. There are two kinds of shapes, and there are also irregular shapes. There is a kind of "positive and negative mutual style" in the balance style, which has a unique composition. The pattern is combined with one positive and one negative to form a rotating effect. The pair is opposite and echoes each other. It is more common on bronze mirrors. Suitable patterns include radial, wave, and rotation, forming a multi-symmetrical shape, which is commonly used in brick carving, ceramics, and bronze mirrors.

The various formation of the patterns in the Yuan, Ming and Qing Dynasties have made greater progress than before and created many new techniques, but from an artistic point of view, they are no longer as grand and flowing as the patterns in the Han and Tang Dynasties. From the Neolithic Age to the Sui and Tang Dynasties, the composition of individual patterns was more rigorously symmetrical; from Song to Qing, the combination of individual patterns was livelier and more balanced. This is a big improvement. Individual patterns are generally still the main pattern, and are commonly used in ceramics, lacquerware, embroidery and architectural paintings. The content is mostly flowers, followed by animals and characters. The balanced style of ceramics with individual patterns, many of which are combined with twisted branches, are vivid and beautiful, rich in decorative effects, and very distinctive. Some

are composed with realistic techniques, and they are all uniform and proper[17]. There is also a form of pure Chinese painting, which is not interesting. Symmetrical composition, ceramics and embroidery are also part of the application in architectural color painting. In the symmetrical type, there are many two-sided and four-sided symmetrical shapes, and the content is mainly flowering and geometric patterns. The shape of individual patterns is round and square. There are also round, diamond, peach and triangle shapes. Separate patterns in the form of rotation are rare, and not as many as the previous generations[18, 19] (Figure 4-5).


Composition of the pattern
Individual style
Bird/Spiral pattern
YAN W. (1965). ON THE STAGES OF YANGSHAO CULTURE IN MIAODIGOU. ACTA ARCHAEOLOGICA SINICA (1), 34
ZHANG P. (1990). ATLAS OF CHINESE PAINTED POTTERY - 2ND EDITION. CULTURAL RELICS PUBLISHING HOUSE.
Fish pattern
CHEN, J., & ZHAO, L. (2015). THE ARTISTIC CHARM OF BIRD TOTEM OF HMONG IN DANZHAI.
New Period Era
(About 18,000 years ago - 1766 B.C.)
Beast pattern
DENG, Y. (2005). ANCIENT CHINESE INVENTIONS (VOL. 5). WUZHOU COMMUNICATION PRESS.
CHEN, J., & ZHAO, L. (2015). THE ARTISTIC CHARM OF BIRD TOTEM OF HMONG IN DANZHAI.
Frog pattern
YUAN, Z. (2021, JUNE). THE WATER PATTERN OF CERAMIC WARE WAS ANALYZED FROM THE PERSPECTIVE OF SEMIOTICS. IN 2ND INTERNATIONAL CONFERENCE ON LANGUAGE, ART AND CULTURAL EXCHANGE (ICLACE 2021) (PP. 495-498). ATLANTIS PRESS.
DENG, Y. (2005). ANCIENT CHINESE INVENTIONS (VOL. 5). WUZHOU COMMUNICATION PRESS.
Shang · Spring and Autumn Period · Western Zhou
(1766 B.C.-771 B.C.)
Symmetrical pattern
JIN, L.I.,& LIYING,Z.H.O.U.(2021). APPLICATION OF HORN PATTERNS OF NOMADIC EMBROIDERY PATTERNS IN ACCESSORIES DESIGN. WOOL TEXTILE JOURNAL, 49(6).
Left-right symmetry
Diagonal symmetry
Multi-sided symmetry
Warring States Period · Qin · Han
(475 B.C. - 220 A.D.)
Four-sided symmetry pattern
JIAN-HUA, Y. A. N. (2012). ON THE MANAGEMENT OF GUIZHOU BY EMPEROR WUDI OF THE HAN DYNASTY. JOURNAL OF JISHOU UNIVERSITY (SOCIAL SCIENCES EDITION), 33(2), 53.
Wave form composition
JIAN-HUA, Y. A. N. (2012). ON THE MANAGEMENT OF GUIZHOU BY EMPEROR WUDI OF THE HAN DYNASTY.JOURNAL OF JISHOU UNIVERSITY (SOCIAL SCIENCES EDITION), 33(2), 53.
Radial composition
PENG, X. (2021, JUNE). A BRIEF ANALYSIS OF HONEYSUCKLE PATTERNS IN WEI, JIN, SOUTHERN AND NORTHERN DYNASTIES. IN 2ND INTERNATIONAL CONFERENCE ON LANGUAGE, ART AND CULTURAL EXCHANGE (ICLACE 2021) (PP. 276-279). ATLANTIS PRESS.
Flower spiral form composition
DUAN, Y., & HUANG, S. (2016). INFORMATION EXTRACTION FROM CHINESE PLANT SPECIES DIVERSITY DESCRIPTION TEXT. DATA ANALYSIS AND KNOWLEDGE DISCOVERY, 32(1), 87-96.

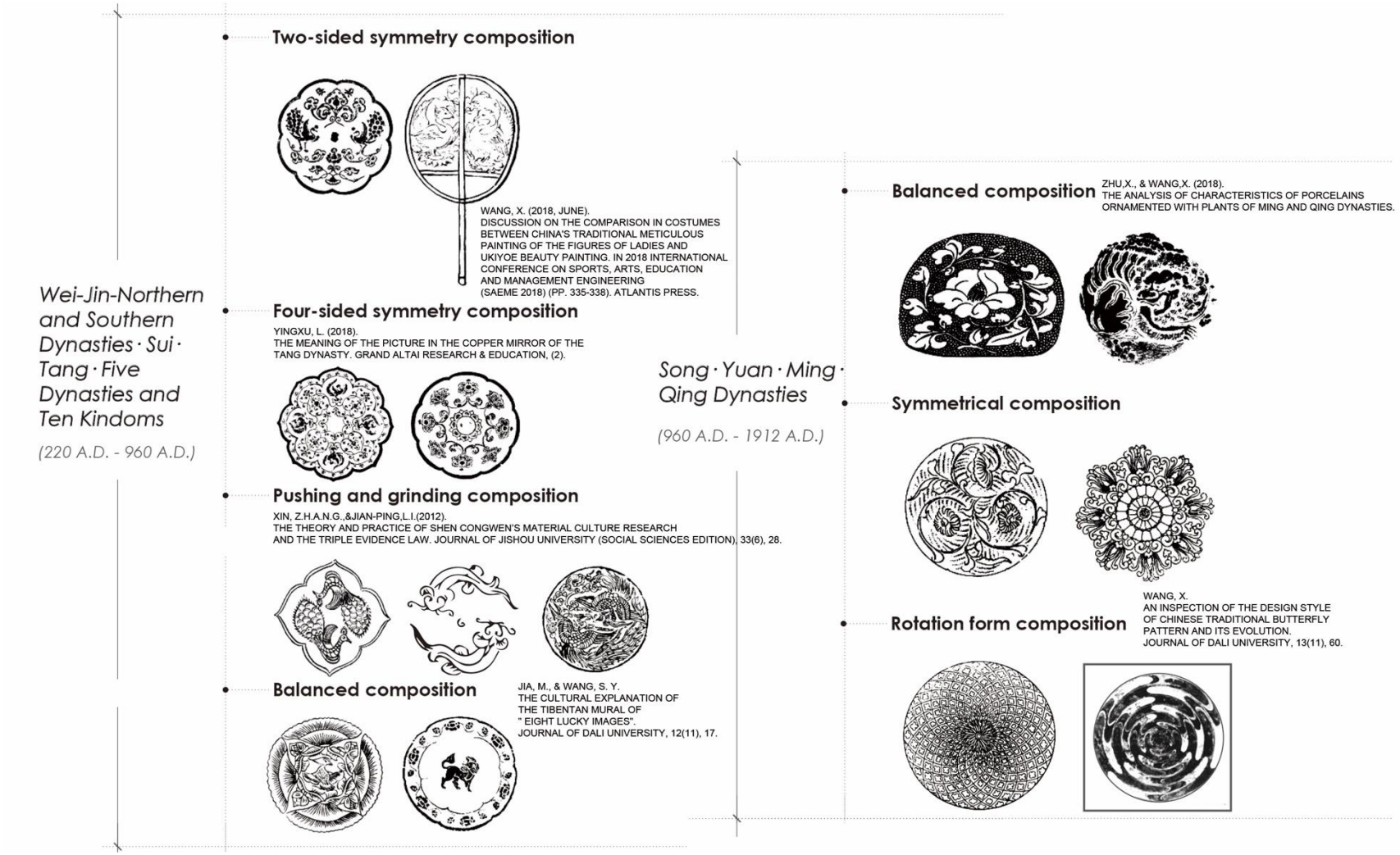


Figure 4-5 Summary and analysis of individual patterns

4.4.2 Continuous style

1. Two-direction continuous

The characteristic of Two-direction Continuous style pattern

The two-direction continuity is the content of the design application. This art form can be seen everywhere in life. It is a pattern formed by a single mode (one model or a combination of two or three models), repeated on "up and down" or "left and right" direction. There are three types of continuous bone structure in two-direction: Vertical type, scattered type, and corrugated type.

The development of Two-direction Continuous style pattern

In the Neolithic Age, the continuous pattern of two squares was widely used, especially on various pottery. Because according to the requirements of the use at the time, the two-sided continuous pattern is simpler and more effective, and can be adapted to all sides (including four-sided and top view) viewing. At that time, the decoration content was mostly geometric patterns, and continuous patterns were composed of geometric shapes, which made it easier to obtain rhythm and unified beauty. Observing from the large number of two-sided continuous patterns left on pottery, jade, bone, and teeth in the Neolithic Age, the composition of the ornamentation generally gradually evolved from simple to complex, but a few evolved from complex to simple. The appearance of the complete skeleton is produced from many irregular and discontinuous patterns after a long period of labor practice. The complete bone style of the continuous pattern is constructed by using equidistant division planes or point positioning methods. The two-sided continuous pattern composition of the Neolithic Age, most of them are horizontal continuous left and right, vertical and oblique patterns are rare. Three scattered points are combined with each other, and there is a repeated arrangement of scattered points. There is another kind of rotating shape and irregular composition. The former is unique, and the latter has no obvious paragraphs. Both of these two forms are rare, especially the latter. There are two-sided symmetrical, four-sided symmetrical and balanced combination of the organization of individual patterns in the two-sided continuous pattern. Among them, the symmetrical is more, and the balance is less. This symmetrical form of unit pattern is adopted to facilitate the continuous effect between individual and individual pattern. The basic bone-type organization of the two-sided continuous pattern, the common ones are the circular type, the broken line type, the diamond type, the wavy type and the scattered point type. And each style has multiple forms in practical application. For example, the broken line organization on Machang-type painted

pottery has multiple combinations such as single broken line, double broken line, triple broken line, quadruple broken line and relative broken line.

The two continuous patterns in the Warring States, Qin and Han Dynasties, mostly composed of geometric content, were used for borders, and the main pattern was very few. There are many horizontal styles, vertical and oblique styles are rare. The bone types are: Wave form. Most of them are composed of wavy lines as the baseline. Due to the different curvatures, lengths, widths and distances of the wavy lines, various artistic effects are produced. This form is more common in stone reliefs and bronze mirror edging. Patterns composed of double-wave lines, double-wave lines intersecting, and multi-wave lines are rare； Scattered form. Most of them are like the Shang and Zhou period, generally composed of one scattered point and two scattered points, and three scattered points are rare； circle form. Some are composed of circles intertwined with each other, some are composed of two semicircles relative to the middle and a circle is filled in the middle, and a circle is connected to the organization； Polyline style. Most of them are composed of horizontal broken lines. There are a combination of single fold lines, a zigzag pattern, and a cross fold line. Among them, it is more common to consist of cross-broken lines. The basic shape is the same as the hook and thunder pattern on the bronzes of Shang and Zhou Dynasties. Its shapes are connected to each other and are often applied to portrait tiles and stone portraits. Irregular two-sided continuous pattern. This kind of ornamentation is often composed of characters and animals, and some have a certain plot. There are two forms of expression, which are arranged in sections with several units; the other is in the form of bands, which cannot be found in the pattern. The latter form is more common, mostly applied to portrait bricks, portrait stones, lacquer pottery and bronzes, etc. It is a popular ornamentation in the Qin and Han dynasties. This form began in the Spring and Autumn Period and the Warring States Period and became popular in the Qin and Han dynasties. The composition form of the continuous patterns of the two squares in this period was the continuation and development of the continuous patterns of the Shang Dynasty, the Western Zhou Dynasty, and the Spring and Autumn Period, with little change.

The two-sided continuous patterns in the Sui and Tang dynasties mostly used flowers as the content. People and animals are often interspersed in flowers. It is rare that they are composed of animals and figures alone, and they are generally used for border decoration. There are many horizontal and vertical forms. The oblique style is rare, and the vertical style is commonly used in inscriptions. In the Warring States, Qin and Han Dynasties, there were many forms of two continuous wave patterns, but most of them were composed of geometric

shapes, and the form was relatively simple. It developed to the Wei, Jin, Southern and Northern Dynasties and Sui, Tang and Five Dynasties, and enhanced the new content of tangled. According to the different content and use, the tangled wave was used as the baseline. The new two-sided continuous pattern of different wave forms has brought the two-sided continuous pattern of wave form to a new stage, becoming one of the most popular patterns in this period.

Most of the fold lines are a combination of horizontal fold lines. Due to the different width, spacing, size, overlap and level of the fold lines, a variety of styles are formed. It is less common to form a cross and a double broken line. Continuous circle. Some are connected by a circle; some are connected by a semicircle; some are opposite by a semicircle, and the middle is connected by a circle. These forms are more familiar in Dunhuang patterns. The common patterns in the Han dynasty were two continuous patterns composed of circles and circles, which are rare in this period. Continuous square. Based on the connection of square and oblique squares, the middle-fill pattern is composed of half squares and oblique squares in the middle； Scattered point type. The form of scattered points is more common, and it is rare to have more than three scattered points composed of one or two scattered points. In this period, there is a two-sided continuous pattern based on a peach shape, some are connected by a peach shape, and some are formed by a half peach shape opposite, and a peach shape is connected in the middle, and the form is beautiful. This kind of composition is extremely rare in previous generations and is a distinctive feature of this period. In the Dunhuang patterns, there are patterns composed of hexagonal and octagonal bones, and a middle-filled pattern. This type of bone formation is more common in brocade patterns, the so-called "turtle pattern". It is less common in the patterns of the previous generations, and it is more common after the Tang and Five Dynasties. It is commonly used in fabrics and architectural decoration.

The two-sided continuous patterns of the Yuan, Ming and Qing dynasties are used in various craft artifacts. The content is mainly flowers, followed by geometric shapes, some interspersed with a few animal patterns; there are also combinations of water and clouds; character subjects are rare. These patterns are used for edge decoration, and they are also used as the main pattern on ceramics. The form is multi-horizontal. Bone styles are mainly composed of various forms such as waveforms, broken lines, scattered points, and squares. In the Sui and Tang Dynasties, it is very rare that the double-wave lines intersect, and the double-wave or multi-wave lines are even more rare. At this time, it is generally composed of winding branches and flowers, mainly flowers, with leaves as lining, for winding back and

forth. The wave-shaped borders of Song Dynasty are composed of spiral coiled leaves. The structure is simple, and the movement is very strong. In the Ming Dynasty, the stone carving pattern of winding branches was composed of a wave of lines up and down. The width of the curled flowers and leaves and the wave lines are the same, and the flowers decorated in each wave are different, and they are diverse in the unity. The Qing Dynasty fabric has a wavy border, and there are flying butterflies between the flowers and fruits, which are static and dynamic, full of interest. The composition of the broken line is basically the same as that of the Tang Dynasty, which is a combination of horizontal broken lines. It is composed of multiple single polylines and overlapping polylines, which is less common than polylines. The content is more geometric. Scattered-point type is one of the oldest traditional forms. It is easy to combine and has been used in various eras. At this time, there are still more than one or two scattered points, and the composition is more diverse than the previous generation. The content is mainly flowers, but also animals. A continuous shape based on squares. Fill in the pattern between each square. There are various combinations of square, rectangular and oblique. At the bottom of Song Dynasty ceramics, there is a petal-shaped overlapping two-sided continuous pattern, and various patterns are filled in the petals. This kind of ornamentation is also more common in the Tang Dynasty, and the form is roughly the same. Three-layer overlap, two-layer overlap is rare; in Song Dynasty porcelain, there are two more overlapping layers, and three-layer overlap is rare. This overlapping structure of petals is rare after the Song Dynasty. There is also a kind of edging based on the Ruyi shape. The middle ornament has a beautiful and diverse form. It is commonly used in ceramics, stone carvings and embroidery in the Yuan, Ming and Qing Dynasties. The water pattern is used as a two-sided continuous pattern, which is popular in various decorations during this period, especially in ceramics. The use of different circles and curves shows the turbulent momentum of various water waves. Although the edging is narrow, it feels that the artistic conception is vast. (Figure 4-6).

Composition of the pattern

Two-direction continuous

According to the type of arrangement

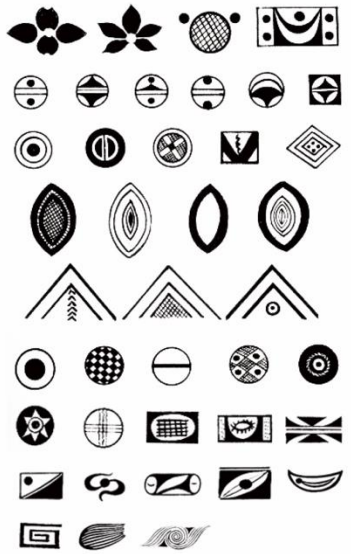
- *Upside-down*
- *One scatter pattern*
- *Two, three scattered pattern*
- *Rotation form composition*
- *Irregular composition*

According to the Basic bone form

- *Circular composition*
- *Discounted composition*
- *Diamond form*
- *Wave form*
- *Scattered composition*

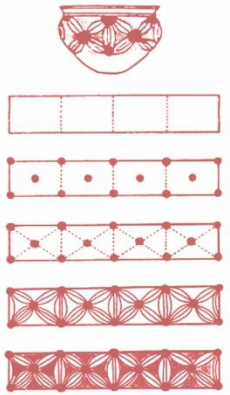
WANG MAN. (2013). RESEARCH ON THE DECORATIVE FEATURES OF PAINTED POTTERY WITH BIRD PATTERNS IN THE NEOLITHIC AGE. CHINESE CERAMICS (3), 4.

Unit pattern



WU SHAN. (2009).
THE COMPLETE WORKS OF CHINESE PATTERNS (4 VOLUMES).
SHANDONG FINE ARTS PUBLISHING PRESS.

Diagram of composition steps



1.Draw the zoning surface
2.Positioning with points
3.Crossed lines
4.Traced by curved lines
5.Fill in the color

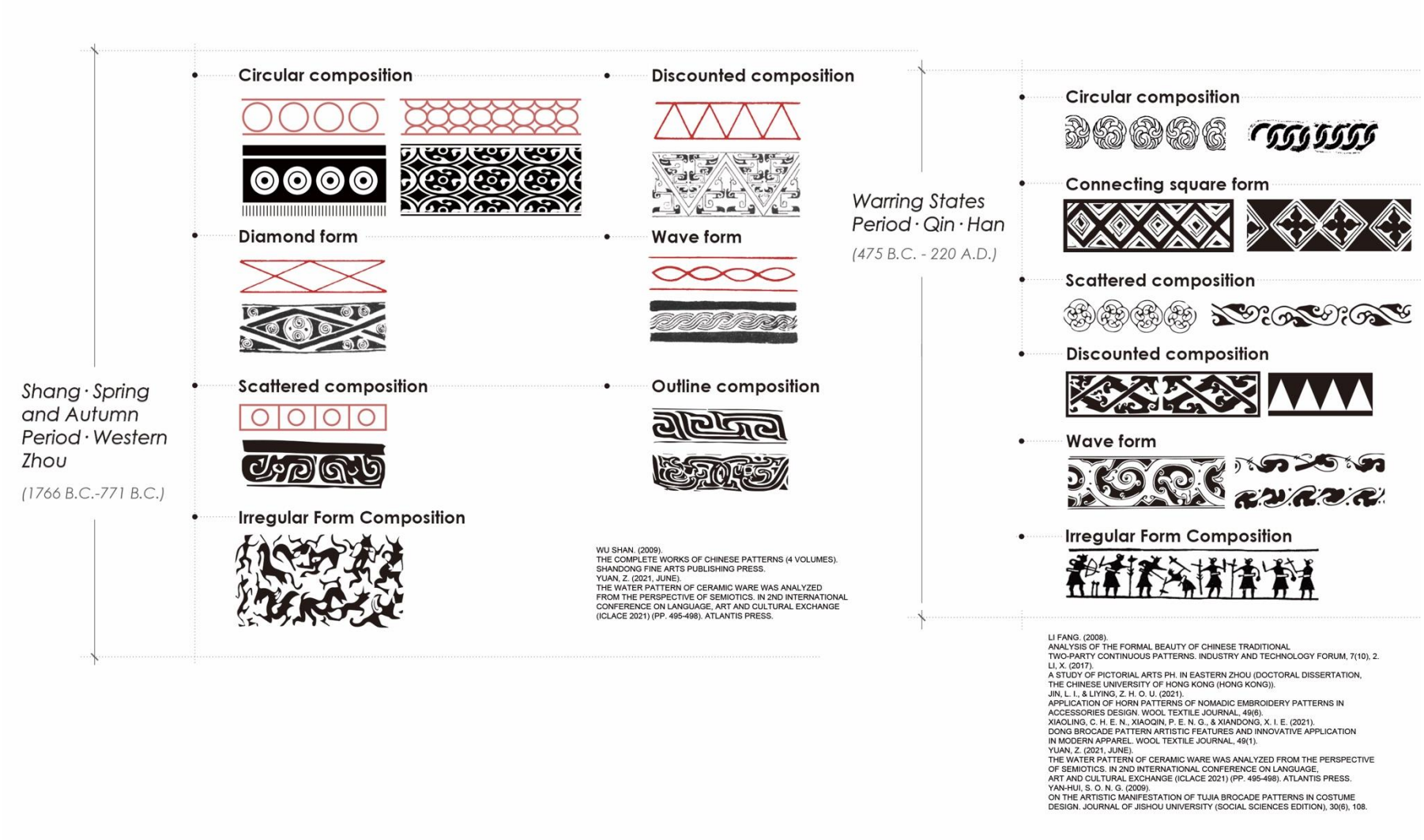
WU SHAN. (2009).
THE COMPLETE WORKS OF CHINESE PATTERNS (4 VOLUMES).
SHANDONG FINE ARTS PUBLISHING PRESS.

LI NENGJIAO. (2020).
STUDY ON THE PATTERNS OF PAINTED POTTERY WITH HOOKED VORTEX PATTERNS IN THE LATE NEOLITHIC PERIOD IN NORTHERN CHINA. (DOCTORAL DISSERTATION, LIAONING UNIVERSITY).

New Period Era

(About 18,000 years ago - 1766 B.C.)

MA CHENGYUAN. (1957). PAINTED POTTERY OF YANGSHAO CULTURE. SHANGHAI PEOPLE'S PUBLISHING PRESS
XI'AN BANPO MUSEUM. (1982). XI'AN BANPO. CULTURAL RELICS PUBLISHING PRESS.
INSTITUTE OF ARCHAEOLOGY, CHINESE ACADEMY OF SCIENCES. (1959). MIAODIGOU AND SANLI BRIDGE. SCIENCE PRESS.
LANG SHUDE. (2004). PAINTED POTTERY. DUNHUANG LITERATURE AND ART PUBLISHING PRESS.
SHANDONG PROVINCIAL CULTURAL RELICS MANAGEMENT OFFICE. (1974). DAWENKOU. CULTURAL RELICS PUBLISHING PRESS.



WU SHAN. (2009).
THE COMPLETE WORKS OF CHINESE PATTERNS (4 VOLUMES).
SHANDONG FINE ARTS PUBLISHING PRESS.
YUAN, Z. (2021, JUNE).
THE WATER PATTERN OF CERAMIC WARE WAS ANALYZED
FROM THE PERSPECTIVE OF SEMIOTICS. IN 2ND INTERNATIONAL
CONFERENCE ON LANGUAGE, ART AND CULTURAL EXCHANGE
(ICLACE 2021) (PP. 495-498). ATLANTIS PRESS.

LI FANG. (2008).
ANALYSIS OF THE FORMAL BEAUTY OF CHINESE TRADITIONAL
TWO-PARTY CONTINUOUS PATTERNS. INDUSTRY AND TECHNOLOGY FORUM, 7(10), 2.
LI, X. (2017).
A STUDY OF PICTORIAL ARTS PH. IN EASTERN ZHOU (DOCTORAL DISSERTATION,
THE CHINESE UNIVERSITY OF HONG KONG (HONG KONG)).
JIN, L. I., & LIYING, Z. H. O. U. (2021).
APPLICATION OF HORN PATTERNS OF NOMADIC EMBROIDERY PATTERNS IN
ACCESSORIES DESIGN. WOOL TEXTILE JOURNAL, 49(6).
XIAOLING, C. H. E. N., XIAQQIN, P. E. N. G., & XIANDONG, X. I. E. (2021).
DONG BROCADE PATTERN ARTISTIC FEATURES AND INNOVATIVE APPLICATION
IN MODERN APPAREL. WOOL TEXTILE JOURNAL, 49(1).
YUAN, Z. (2021, JUNE).
THE WATER PATTERN OF CERAMIC WARE WAS ANALYZED FROM THE PERSPECTIVE
OF SEMIOTICS. IN 2ND INTERNATIONAL CONFERENCE ON LANGUAGE,
ART AND CULTURAL EXCHANGE (ICLACE 2021) (PP. 495-498). ATLANTIS PRESS.
YAN-HUI, S. O. N. G. (2009).
ON THE ARTISTIC MANIFESTATION OF TUJIA BROCADE PATTERNS IN COSTUME
DESIGN. JOURNAL OF JISHOU UNIVERSITY (SOCIAL SCIENCES EDITION), 30(6), 108.

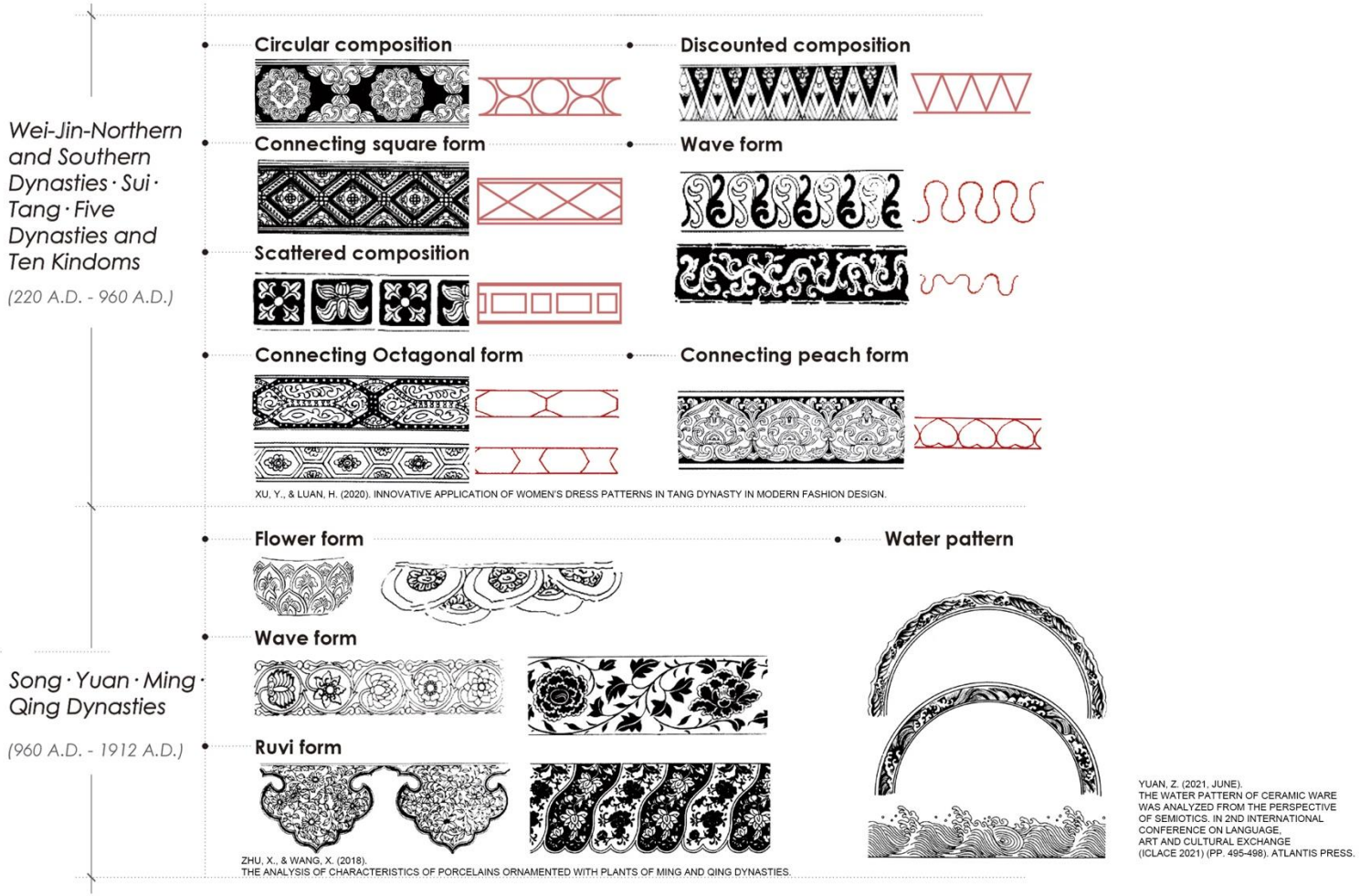


Figure 4-6 Summary and analysis of Two-direction continuous patterns

2. Four-direction continuous

The characteristic of Four-direction Continuous style pattern

The four-direction continuity is a pattern obtained by arranging and extending one mode unit within up, down, left, and right four directions. The four-direction continuous pattern usually used for large-scale decorations, such as flower cloth, wrapping paper, wallpaper, floor tiles, etc. There are three types of bone structure in four directions: Scattered points, dislocations, and overlaps.

The development of Four-direction Continuous style pattern

In the Neolithic Age, the continuous tetragonal pattern was not widely used. Most of them are meshed and created by the inspiration of woven fabrics. The basic composition method of the Four-direction Continuous pattern is a mesh structure, including squares, triangles, rhombuses, rhombuses, rectangles and parallelograms. Most of these organizational forms are already available in the decorative arts of the Neolithic Age, and some of them are many. The continuous patterns of the Neolithic Age are almost absent on jade and bones. The Four-direction Continuous pattern is the most diverse in the mesh organization. There are more than ten different methods for only one mesh in the rhombic organization. Followed by the two-square connecting form, the diamond-shaped connecting form, and the arrangement of a scattered point. On the colored pottery of the Yangbu culture, it is common to use the continuous pattern of the square and other patterns mixed together. On geometric printed pottery, there are many applications of continuous square patterns, which are related to the production process of the printing and the production tools (such as pottery rackets). The skeleton of various patterns in the Neolithic Age can mostly be changed according to the shape of the vessel. Generally speaking, in the treatment of art, preliminary attention has been paid to striving to balance, reconcile and maintain the equality of "power", the contrast methods of black and white, virtual and real, height, weight, thickness, size, density, interval, etc. Level. The composition of continuous patterns pays attention to the neat and uniform technique, and the artistic effect is better. Among them, there are a few patterns, the composition is more unique, there are asymmetries in symmetry, and discontinuities in continuity, which appear free and flexible.

During the Warring States period and the Qin and Han Dynasties, the four-direction continuous patterns were mostly used on fabrics and portrait tiles, but not much on other artifacts. The main forms of composition are the continuous connection type has square connection, round connection, rhombus connection, oblique square connection and two

continuous connection. There are one scatter point and two scatter points in the scatter point formula, and more than three scatter points are rare. The four-direction continuous pattern on the portrait bricks of this period was first made with a unit pattern mold and printed into continuous patterns in equal parts while the bricks were still wet. This kind of pattern is generally composed of square or oblique square, mainly for the convenience of printing and calculation. The form of individual patterns is divided by diagonal lines to form a four-sided symmetrical telecentric or heart-seeking pattern. This is mainly designed to achieve a better coordinated continuous effect. On the Han Dynasty portrait tiles, richer artistic effects can be achieved by changing the position of printing, the number of spaces (one virtual and one real), the difference in arrangement, and the combination of two or more different units. (Picture 48) This kind of newly created combination forms opened up a broad way for future generations to form a continuous pattern of square patterns. The continuous four-square patterns of the Warring States, Qin and Han Dynasties are more rigorous, diverse and flexible than the Shang Dynasty, Western Zhou, Spring and Autumn Period, and the continuous effect is better.

Most of the continuous patterns in the Wei, Jin, Southern and Northern Dynasties, Sui and Tang Dynasties are expressed on fabrics. The traditional continuous and scattered composition has been greatly developed, and new forms such as turtle back and twisted branches have been created, which are quite distinctive.

Concatenation is a traditional form and one of the most popular skeletons at that time. Common forms include round, diamond, two-sided, and turtle-back connections. Round-shaped continuous decoration, commonly known as group flower continuous decoration. Since the Wei, Jin, Southern and Northern Dynasties, it has continuously absorbed the nutrition of foreign art, and a fancy composition of Lianzhu Tuan appeared, which gradually formed into a format, which was one of the popular pattern composition methods at that time. Some linked beads are closely arranged, and some are sparsely arranged; some linked beads are large or small, more or less; some linked beads have sun patterns, and some have negative patterns, which are also used without the beads. It is composed of thick and thin lines; some are composed of flowers. Most of the spaces inside and outside the flowers are filled with flowers, birds and beasts, and some use figures and geometric patterns. Birds and beasts are mostly arranged in pairs. Lianzhu Tuan flowers[20] are all connected in circles and rows, and the composition has obvious new characteristics. During the Han Dynasty, the circular continuous decorations were mainly shown on the portrait tiles, which were rarely seen on the fabrics, and the forms were dull. In the Sui and Tang Dynasties, the changes were

abundant, lively and vivid, and various forms. The rhombus is a traditional composition technique in the Han Dynasty, and there are new developments in this period. Some of the skeletons are connected by small dots, some are composed of small flowers, and some are expressed by lines. Some flowers are filled in the middle of the rhombus, and some are clothed with bird and beast patterns. The two-direction continuum is an ancient traditional composition technique that has been applied since the primitive society of painted pottery. It is composed of two successive layers. During the Wei, Jin, Southern and Northern Dynasties, this method was also commonly used, and gradually decreased in the Sui, Tang, and Five Dynasties. Relative and staggered arrangements are generally more common. Turtle continuous is a new style of this period. The tortoise-back pattern brocade of the Tang Dynasty unearthed in Astana, Turpan, Xinjiang. The tortoise's back is composed of four squares on all sides, and the center of the tortoise's back is a plum blossom pattern with contrasting squares.

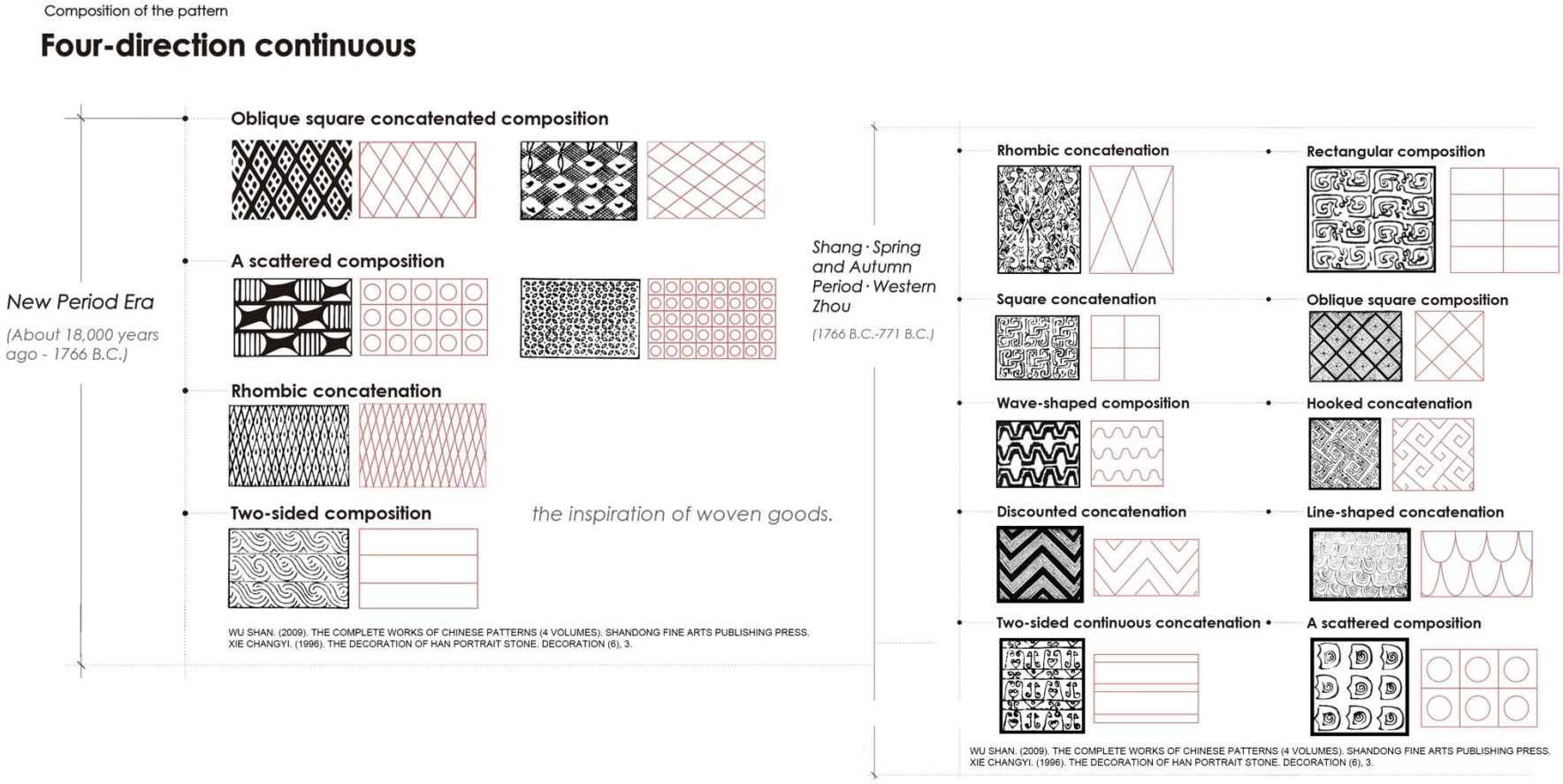
Scattered point type. The traditional composition technique is still used, one or two more scattered points are used, and more than three scattered points are rare. Scattered composition was one of the popular methods at that time, and scattered dots with group flowers were more common. The cluster flowers are generally the main flowers. Between the four cluster flowers, due to the difference in size and spacing, a diamond-shaped gap is formed, and most of the gaps form a radial diamond-shaped pattern. The cluster flowers are composed of blooming flowers, some have a wreath around the flowers, and some are formed radially looking down, and there are also entangled branches. Due to the difference in arrangement size and color between the group flower and the group flower, between the group flower and the corner flower, the artistic effects of mutual reference, complementary radii and bright primary and secondary are formed. Some are composed of concise and sparse scattered points; others are composed of closely connected techniques, which have the artistic effect of flowers all over the floor.

Tangled formula. At this time, the emerging pattern of wrapping branches can also be seen applied to brocade, with flowers and branches interspersed continuously in all directions, and characters, birds and beasts are arranged in between. The tangled branch-like tetragonal continuous pattern will be applied to the fabric in the future. It has been used for many days, and it has been developed to this day, and it is still a popular style. The tetragonal continuous patterns of this period are the same as those of the Han Dynasty, and there are generally no ground patterns.

The four-direction continuous patterns in the Yuan, Ming and Qing Dynasties are more complex and diverse than in the Tang Dynasty. In terms of the layout of chapters and methods, with the development and improvement of production technology, many new techniques have been created, mainly in the aspects of weaving, embroidery and construction. The content of the fabric is mainly flowers, followed by geometric patterns. In this period, the unit patterns in the format include cluster flowers, folded branches, twisted branches, scattered flowers, full-fledged flowers, and geometric patterns. Take the group flower as an example. According to different fabric widths and uses, different numbers of group flowers are arranged, including single flower, two flower, three flower, four flower, five flower, six flower and eight flowers. The term refers to the number of tufts as "sets", one tuft is one set, two are two sets, and three are three sets. Some flowers have different patterns, some use units to change direction, and some have different colors. These are all new methods created during this period. The skeleton is composed of continuous type, entangled branch type, scattered point type, overlapping type and so on. The basic skeleton in the continuous style is a mesh structure, and the basic shapes include square, oblique, rectangular and rhombus. The continuous pattern is one of the oldest traditional forms. It has been applied to the printed pottery of the Neolithic Age. At that time, the two-sided continuous pattern was the most common. In the Song Dynasty, the more popular consecutive styles include pingqi grid, turtle back, square win and ball road. The Yuan Dynasty took the costume patterns of the Yongle Palace mural paintings as an example. In addition to the styles that were passed down in the Song Dynasty, there were also "Four Out", "Shidi", "Tuandoubaozhao", "Edged Body Fitting Halo" and "Lianzhu He Halo" Wait. During the Ming and Qing Dynasties, on the basis of the Song and Yuan traditions, each style had many changes, and the composition was more complicated. In this period, the rhombus, tortoise back, stage, wave, and two-sided combination are the most common and diverse. Rhombus concatenation is one of the traditional composition techniques. Generally, suitable patterns are filled into the rhombus, and a small part of the pattern is filled beyond the rhombus line. Most of them are composed of flowers, and some are composed of geometric shapes, colorful butterflies, fish and insects. A large rhombus, four corners and five small rhombuses in the middle form the so-called "square win pattern", which is a popular pattern in the Han Dynasty. It was produced in a small amount during the Song and Yuan Dynasties, and it is rare in the future. In the Ming and Qing Dynasties, there was a form of interlocking rhombuses, with patterns in the middle, which is unique and a new style. The tortoise-back is a form of bone structure created in the Tang Dynasty, and it was still popular in the Song, Yuan, Ming and Qing dynasties. It is generally based on the hexagonal connection, with various flower, bird, and animal patterns in the middle. In the combination, due to the different sizes and arrangements of the

hexagons, the filled patterns are different, which can form a variety of artistic effects. There are many consecutive styles of stages, such as one-half, one-third, one-quarter, and one-fifth stages. In the fabrics of the Ming and Qing Dynasties, one-half and one-third stages are common. Waves in this period mainly consist of wave-line relative, intersecting, double-wave and single-wave methods. Some are filled with patterns in the wavy space, some are made up of wavy curves, and some are made up of a combination of the two. The two-sided continuous embellishment has been applied to the Neolithic-colored pottery. Because the organization is simple and the effect is better, it has been used all the time. In this period, the two-sided continuous patterns were common skeletons, and there were individual patterns that were arranged oppositely and staggered, and there were also two different continuous patterns of two-sided, which were arranged in rotation. The entanglement structure was very mature in the Sui and Tang Dynasties, and developed to Song, Yuan, Ming and Qing, with more diverse composition techniques. The basic skeleton is composed of spiral, S-shaped, and wave-shaped as the main trunk line, which is wound in series according to a certain rule. The flowers are arranged in important parts of the tangled branches. The branches and leaves move back and intersperse around the main flower. The tangled branches, the main flowers and leaves, the size, the density, the virtual and the reality reflect each other, echo each other, and harmonize with each other. Scattered composition has been used in the Neolithic Age, and most of them are a scattered composition. There are usually one to six scattered spots in Song, Yuan, Ming and Qing dynasties, and more than seven are rare. The arrangement of the scattered dot pattern, some have direction, some are non-direction, and the application with direction is more. The overlapping form constitutes this skeleton, which was less used in the Han Dynasty to Sui and Tang Dynasties, and developed to the Ming and Qing Dynasties, and became popular on brocade again. It is common to use various brocade patterns, water patterns, ice cracks, etc. as the shading, and the floating patterns have various flowers, birds and fish. The shading is mostly composed of continuous patterns, and the floating patterns are all scattered dots. There is also a pattern that combines geometric shapes and natural patterns. It is usually based on the geometric shape of the "M" character lattice, with a large cluster of flowers in the center, and eight patterns on the top, bottom, left, and right corners, and the four corners. Patterns, in the gaps of the rice-shaped grid, painted various geometric patterns or flower patterns, up to eight kinds, commonly known as "eight halos", the term is called "Jinqun" (fingerprint ornaments are used more frequently). Its characteristic is to win with more patterns. Although there are many patterns in each part, the overall effect is unified and harmonious, the structure is well-proportioned, and the color matching is rich. Among all the brocade patterns in the past dynasties, the Bada halo brocade is the most complicated. This brocade style was relatively simple in the Tang Dynasty, with many geometric patterns.

In the Song Dynasty, the flower clusters had many natural flower shapes, and the composition became more and more complex. Development to the Ming and Qing Dynasties more complex layout, more changes (Figure 4-7).


Composition of the pattern
Four-direction continuous
New Period Era
(About 18,000 years ago - 1766 B.C.)
Oblique square concatenated composition
A scattered composition
Rhombic concatenation
Two-sided composition
the inspiration of woven goods.
WU SHAN. (2009). THE COMPLETE WORKS OF CHINESE PATTERNS (4 VOLUMES). SHANDONG FINE ARTS PUBLISHING PRESS.
XIE CHANGYI. (1996). THE DECORATION OF HAN PORTRAIT STONE. DECORATION (6), 3.
Shang · Spring and Autumn Period · Western Zhou
(1766 B.C.-771 B.C.)
Rhombic concatenation
Rectangular composition
Square concatenation
Oblique square composition
Wave-shaped composition
Hooked concatenation
Discounted concatenation
Line-shaped concatenation
Two-sided continuous concatenation
A scattered composition
WU SHAN. (2009). THE COMPLETE WORKS OF CHINESE PATTERNS (4 VOLUMES). SHANDONG FINE ARTS PUBLISHING PRESS.
XIE CHANGYI. (1996). THE DECORATION OF HAN PORTRAIT STONE. DECORATION (6), 3.

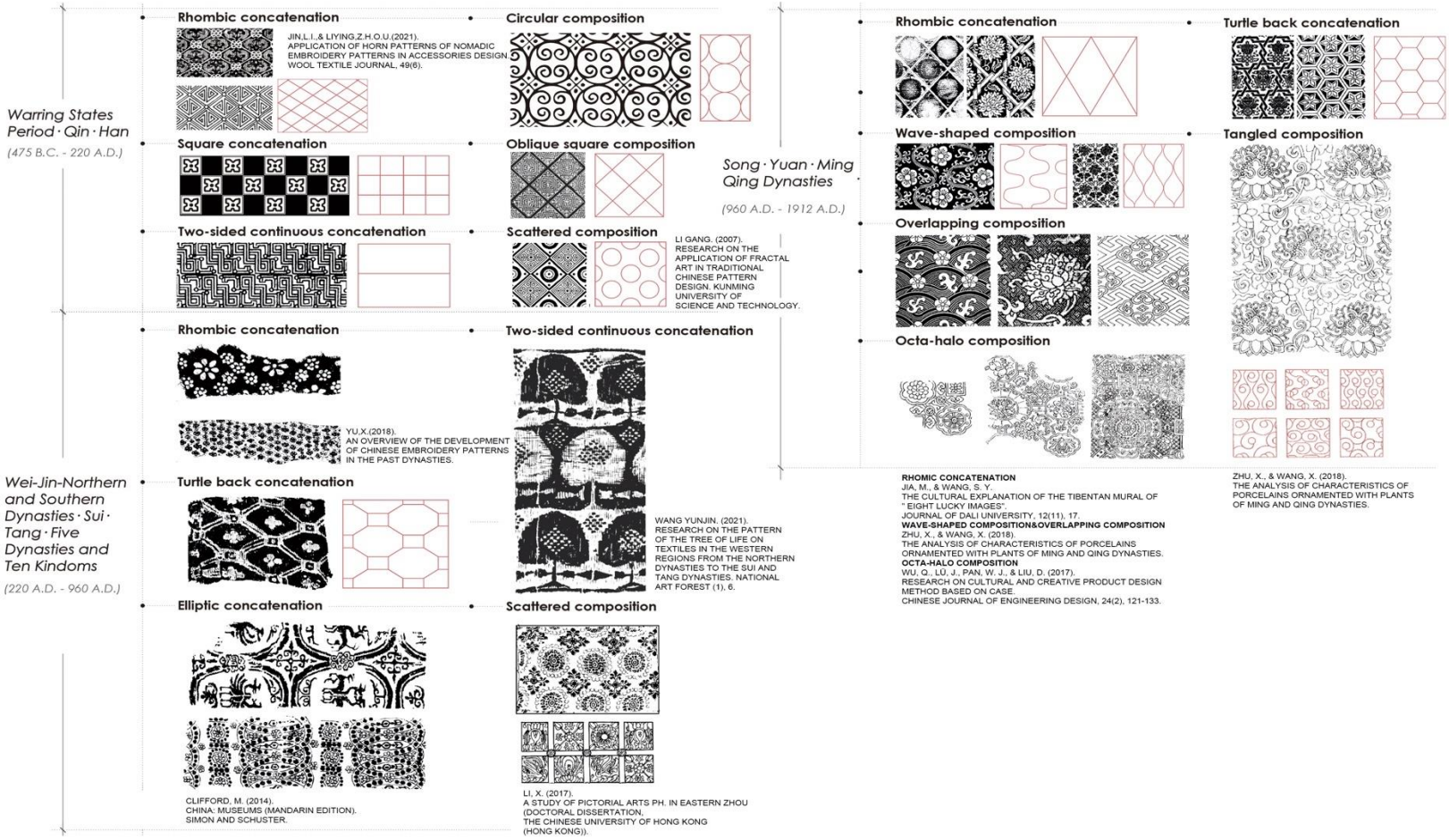


Figure 4-7 Summary and analysis of Four-direction continuous patterns

4.4.3 Appropriate style

The characteristic of Appropriate style pattern

Appropriate patterns are rigorous and practical. The changes in patterns not only reflect the characteristics of objects but are also interspersed with nature, which forms the independent decorative beauty. The pattern is complete in shape. The internal structure and external form are cleverly combined. It is often used independently for arts and crafts decoration.

The development of Appropriate style pattern

The irregular painting patterns of Wei, Jin, Southern and Northern Dynasties, Sui, Tang and Five Dynasties have new developments on the basis of inheriting the traditions of the Han Dynasty. Mainly characters, most of them have definite plots, emphasizing spiritual portrayal, full and well-proportioned layout, and rich in decorativeness. Used in stone carvings, bronze mirrors, gold and silverware, etc. Some of the composition still adopts the traditional method of subdivided chapters, divided into several stages according to the content, using parallel arrangement, rigorous organization, regularity in shaping the image, strong stylization, multi-faceted description, and striving for simplicity and clarity. The depiction of the theme is distinct and vivid. There is also a form of applied painting organization, which is commonly used in screens and other places, and was used more in dyeing at the time. Generally, in terms of composition, there are flowers and trees on the top, sheep and deer or birds under the trees, most of which are combined in pairs, much like paintings of flowers and birds, and there are also landscapes. (Picture 80) This form of composition was influenced by the paintings of flowers, birds and landscapes at that time. After the Five Dynasties, this painting style composition gradually occupied an important position in the pattern. The above several composition forms are a unique structure in Chinese patterns. This kind of composition emerged during the Warring States Period, and gradually matured in the Wei, Jin, Southern and Northern Dynasties, Sui, Tang and Five Dynasties. It interacted with the painting art at that time. The style gradually broke away from stylization and turned to realism. The Sui and Tang Dynasties were a turning point.

Appropriate patterns after the Yuan Dynasty gradually lost the characteristics of decorative art, and some were purely a form of Chinese painting, especially during the Ming and Qing dynasties. This tendency became more and more obvious. The painting patterns of this period are mainly manifested in ceramics, embroidery, tapestry, lacquerware and

architectural paintings. The content includes flowers and birds, figures, landscapes and so on. Many of the painting patterns of the Ming and Qing Dynasties were imitated by famous painters of the time, especially blue and white and colored porcelain. The patterns of the Qing Dynasty were neat in the early stage, sluggish in the middle stage, and rough in the later stage. The painting patterns of Song, Yuan, Ming, and Qing are all used as the main pattern and arranged in the center of the utensil. Generally, simple geometric borders are added to the outside. Edging.

4.5 The skeleton order of Chinese patterns

Regardless of the style of the pattern and the combination method, it is formed on the corresponding skeleton structure, following the typical classic logic. Summarize the rhythmic sense of the patterns with simple basic geometric shapes. These ever-changing graphic patterns are all based on the extension and expansion of a specific skeleton structure. The distribution rhythm can be quantified. Even the most complicated patterns can be subjected to modulus analysis and disassembled into delicate components that can be assembled and decomposed. The linking activities between elements have a general law analysis after the basis of quantitative analysis. We use drawing and mathematical methods to convert them into a computer-operable language, which becomes the basis for parameterizing graphics (Figure 4-8).

Figure 4-8 Skeleton Analysis

4.5.1 Tai chi graphic and circle pattern

Tai chi, sometimes colloquially known as "Shadowboxing," [21] is an internal Chinese martial art practised for defence training, health benefits, and meditation.

The circular pattern in China is directly related to the ancient Chinese culture “Tai chi” motif, a kind of graphic with an S-shaped line in a perfect circular bisect. The line divides the whole circle into two parts: The interaction between Yin and Yang, endlessly turning with a circle center (Figure 4-9).

The “Tai chi” motif represents a kind of movement where the realities are complementary, as China’s philosophical idea of the unity of opposites. The S-shaped line pattern is dynamic

and changeable. It achieves a unique mood in its form under the support of pattern skeleton structure. Analyze it by the coordinate axis. All activities are around a fixed center point, which is the origin. We combine the areas divided by the extended X and Y axes in the form of curve intersections. The pattern formed in this way is more vibrant than the layered pattern as a matryoshka. The participation of the curve can make people more visually enjoyable rather than being restricted by logic.

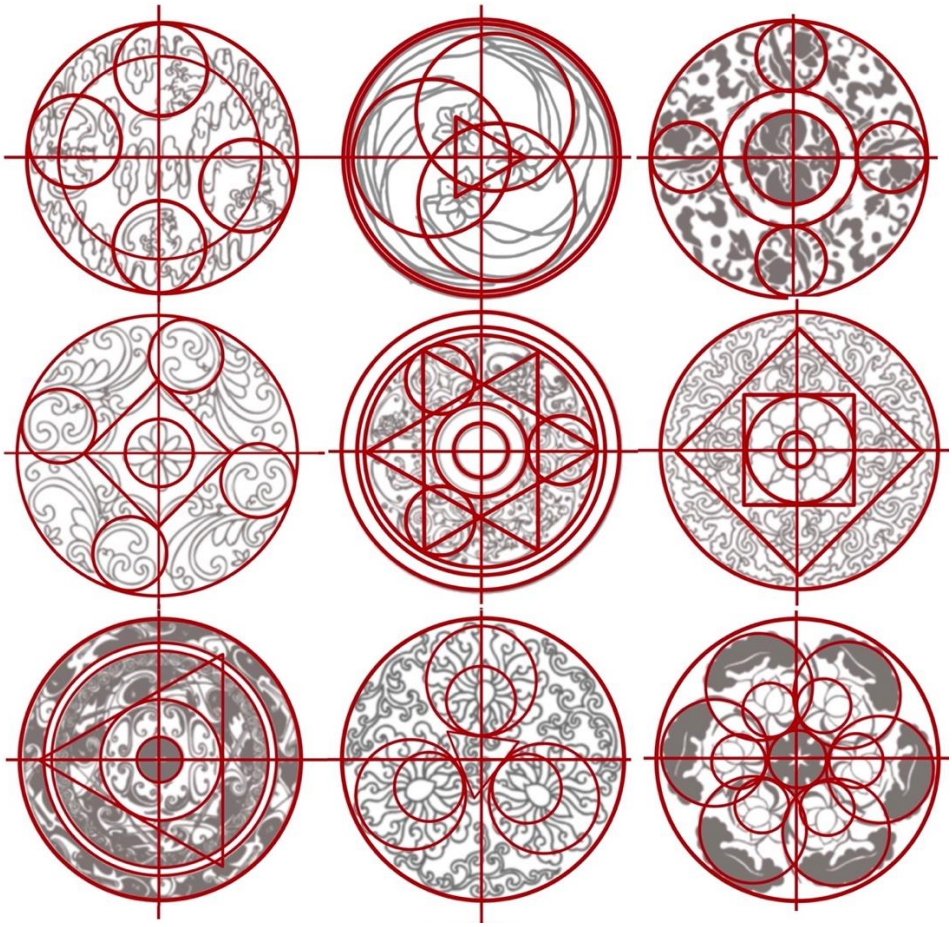


Figure 4-9 Tai chi and circle

4.5.2 Grid skeleton

There is an old Chinese saying, “everything has its counterpart”. That is “Even”. In Chinese tradition, “Even” is the beauty. Architecture and music are also based on the principle of “Even” as beauty. People in the “Tang” Dynasty (618-907) studied calligraphy and copied the

inscriptions on a square grid. One big network can be divided into nine small grids, like the Ming (1368-1644) Emperor's "Jiu gong" grid of the ancient emperor. In the Qing Dynasty (1636-1911), there were thirty-six minor divisions in one grid, which was named "New Jiu gong" Style. "Jiu gong" style means: Two and four in front, six and eight in back, left three right seven, left nine right one, five in center". The diagram is arranged in order, horizontally, vertically or 45-degree Angled, all three numbers add up to 15, it is also called Magic square. It began to appear in the works of Song Dynasty mathematician Yang Hui in the 13th century AD. The compilation method is as follows[22, 23].:

1: First draw a square diagonally, divide it into 9 small squares in the middle, and then fill in 1-9 one by one (Figure a). Next, in this obliquely drawn square, take a square drawn as shown by the dotted line. It is still divided into 9 cells, 4 of which are empty (Figure b).

2: Finally, replace the remaining 4 numbers with up, down, left, and right, and fill in the blanks. This is to use transposition to make magic squares. In fact, all magic squares with odd rows can be compiled by this method.

"No rules, no standards", in Han Dynasty (206BC-220AD) it has already begun to pay attention to "rules". Like the network map pattern on the portrait brick, it contains the law and logic of mathematics as well as "symmetry", "balance", "harmony", and "proportion". The bronze mirror patterns of Han and Tang (618-907) dynasties, the composition of Han stone carvings, and the geometric patterns evolved from the "Jiu gong" all contain the unique mathematical order.

Since the Han Dynasty, there have been two "methods" in the construction of Chinese patterns. One is "four directions and eight azimuths" from the "meter-shaped grid", which based on the geometrical formation of "up and down", "left and right", "diagonal lines". This skeleton is fully reflected in the folk crafts, including batik paintings or the back of the bronze mirror. The other is the Han Dynasty stone carving composition on portrait brick and stone. The "up and down", "left and right", "diagonal lines" are combined into a three-dimensional space structure with "top surface", "side surface", and "front surface", transforming the planar composition into a three-dimensional parallel perspective pattern.

On the fabrics of Mawangdui, rectangular geometric patterns can be seen, indicating that the "rice grid" and "horizontal map" were popular at that time. There is an inner coffin lid decorated with velvet and feather appliques in the Mawangdui cultural relic. The pattern of this ornament is made of a rectangular pattern. In addition, the lacquer patterns unearthed

in Mawangdui are composed of "regular"-shaped patterns, giving full play to the grace of "regular" (circular)-shaped patterns.

The "square" and "circle" in the patterns of the Han Dynasty expressed the beauty of the universe by the unity of square, vertical, horizontal, square and straight, and contradictions. The decorative beauty of the pattern was sublimated to the beauty of "rules" suitable for the Han culture at that time. The era style of the Han pattern. The silk paintings, fabrics, embroidery, and lacquerware from Mawangdui collectively reflect the characteristics of this era.

When people are trying to abstract something, they are willing to go the other way and choose some logically regular expressions that can be controlled by the human brain. Therefore, the patterns extracted by human processing have distinct structural rules. The display of traditional Chinese motifs is mostly represented on the style of two-dimensional graphics in the form of curves and natural shapes. In the complex pattern system, the essential elements interact and support each other, describing the ecological collection of sophisticated space. Before design practice, it is necessary to understand the structure order and to extract the components, the organization of the symbol of the element. These elements will bring the historical style and life vitality to the three-dimensional pattern structure. As the lines and color blocks from artists, they are full of perceptual expression. In the creative process, the designers add more efficient structural perceptual vitality components using rulers, with computers and other auxiliary tools. For example, the cloudscape in Shang (1600BC–1046BC) and Zhou Dynasties is mainly an S-shaped, T-shaped cloud pattern and hook moire pattern, in Wei (220–280) and Jin (265–420) Dynasties it appeared as a cloud pattern combined with a prominent head and tail.

4.6 The conclusions for graph theory study

In this chapter, by analyzing the composition and skeleton of patterns and traditional Chinese patterns, the conclusions are as follows:

1) Pattern analysis provides a method. The logic of pattern graphics is mostly based on visual cognition. The first step in visual cognition is orderly and simple. Find the mathematical relationship among them by simplifying and cumbersome analysis.

2) Analyzing the composition of traditional Chinese styles in this way, it can be found that the composition method has developed from the original single mode to four directions, and the expressions tend to be complicated and diversified in the way of mirroring or copying. Extending to the next step, whether we can apply this technique to digital operations based on this construction model.

3) In terms of skeleton logic, graphical analysis and drawing can show that a single element has skeleton logic in its composition, including the modulus relationship and position relationship of geometric patterns in the skeleton, the logical relationship of element placement. At the same time, it also takes into account the principles of balance, unity, and order in traditional Chinese thought. This multi-factor embedded framework allows designers to think more broadly and maintain control over the entire design.

Reference

1. Arnheim, R., Art and visual perception. 1960: Stockholms Universitet, Institutionen för Konstvetenskap.
2. Kennedy, J.M., The Sense of Order: A Study in the Psychology of Decorative Art. 1980, JSTOR.
3. Douat, D., Methode pour faire une infinité de desseins differens avec des carreaux mi-partis de deux couleurs par une ligne diagonal. 1722: chez Florentin de Laulne.
4. Billings, R.W., The Power of Form Applied to Geometric Tracery: One Hundred Designs and Their Foundations Resulting from One Diagram. 1851: W. Blackwood and sons.
5. Billings, R.W., The infinity of geometric design exemplified. 1849: William Blackwood & Sons.
6. Bain, G., Celtic art: the methods of construction. 1973: Courier Corporation.

7. Glassner, A., Celtic Knotwork, Part I. IEEE Computer Graphics and Applications, 1999. 19(05): p. 78-84.

8. Scharein, R.G., Interactive topological drawing. 1998, University of British Columbia.

9. Mercat, C., Les entrelacs des enluminures celtes. Pour la science, 1997: p. Faîtes vos nœuds.

10. Bovill, C. and C. Bovill, Fractal geometry in architecture and design. 1996.

11. Burger, E.B. and M. Starbird, The heart of mathematics: An invitation to effective thinking. 2004: Springer Science & Business Media.

12. Benoit, B.M., Fractals: form, chance and dimension. 2020: ECHO POINT Books & MEDIA.

13. Mandelbrot, B.B. and B.B. Mandelbrot, The fractal geometry of nature. Vol. 1. 1982: WH freeman New York.

14. Yifu, C., et al., Discuss on the trade and motive force of Majiayao cultural painted pottery in Gansu-Qinghai region. Quaternary Sciences, 2020. 40(2): p. 538-546.

15. Hung, L.-y., Pottery production, mortuary practice, and social complexity in the Majiayao culture, NW China (ca. 5300-4000 BP). 2011: Washington University in St. Louis.

16. Han, H.-k. and S.-h. Yang. A Study on the Fashion Design that Applied the Wadang Pattern-Focused on Quilt Techniques. in Proceedings of the Costume Culture Conference. 2004. The Costume Culture Association.

17. Zibing, T., Arts & Crafts and Aesthetics.

18. Zibing, T., China's craft art history. 1996, Oriental Publishing Center.

19. Tian, Z., History of Chinese arts and crafts. Shanghai: Oriental Publishing Center, the first edition, 1985. 1.

20. Zhou, G., Cultural Implication of Jiarong Tibetan Brocade Belt. Scientific and Social Research, 2021. 3(1).

21. Defoort, C., Is there such a thing as Chinese philosophy? Arguments of an implicit debate. Philosophy East and West, 2001: p. 393-413.

22. Cammann, S., The evolution of magic squares in China. Journal of the American Oriental Society, 1960. 80(2): p. 116-124.

23. Swetz, F., Legacy of the Luoshu: The 4,000 Year Search for the Meaning of the Magic Square of Order Three. 2008: CRC Press.

Chapter 5 Design practice

5.1 Introduction

This Chapter focus on the process of the combination of Architecture Design and traditional culture, revealing the possible design form of digital modeling-based traditional pattern conception.

Take the traditional pattern as a prototype. Abstract and transform the essential elements. Combine the regenerated model with the existing old building. The experiments are based on traditional pattern graphics. First step: Confirm the graphic logic and modulus relationship behind individual patterns and continuous patterns from their essence. Describe the relationship or structure from the accurate perspective of graphics. Complete the interpretation from graphics to diagrams in the design. Under digital technology, the designers try to transform complex and multi-category information into measurable numbers and data. Complex patterns are embodied, realistic, and refined into single elements which can be used for design. It is a process from complex to simple. Then, through software processing, digital models are more sculptural. Designers use digital technology to break the standard interface orthogonal relationship of building. They try to apply shapes with free-form surfaces and irregular morphological interfaces to structures. Extremely complicated geometric forms under the control of parameters constitute a variety of visual effects with limited components. The use of these complex components in architecture makes the building more contemporary and impactful. That is, it demonstrates the value of multiple aesthetics and sociality. It is a process from simple to complex.

Two experiments are introduced to demonstrate how modeling tools are applied into the design process and what characteristics of traditional patterns enable multi-level thinking and ensure data passes to the next process and the entire workflow. Experiment 1 is based on the extraction of elements and the multi-directional expansion of elements. Experiment 2 is a further step on the basis of Experiment 1, applying the redesign based on the traditional pattern to the old building, observing its physical performance, and looking for more possibilities（Figure 5-1）

The purpose of the study is the multi-pattern expression can break the propagation dilemma of the two-dimensional direct copy expression of traditional patterns; The

advantages of modern modeling technology help traditional patterns to remove flattening and express dynamic.

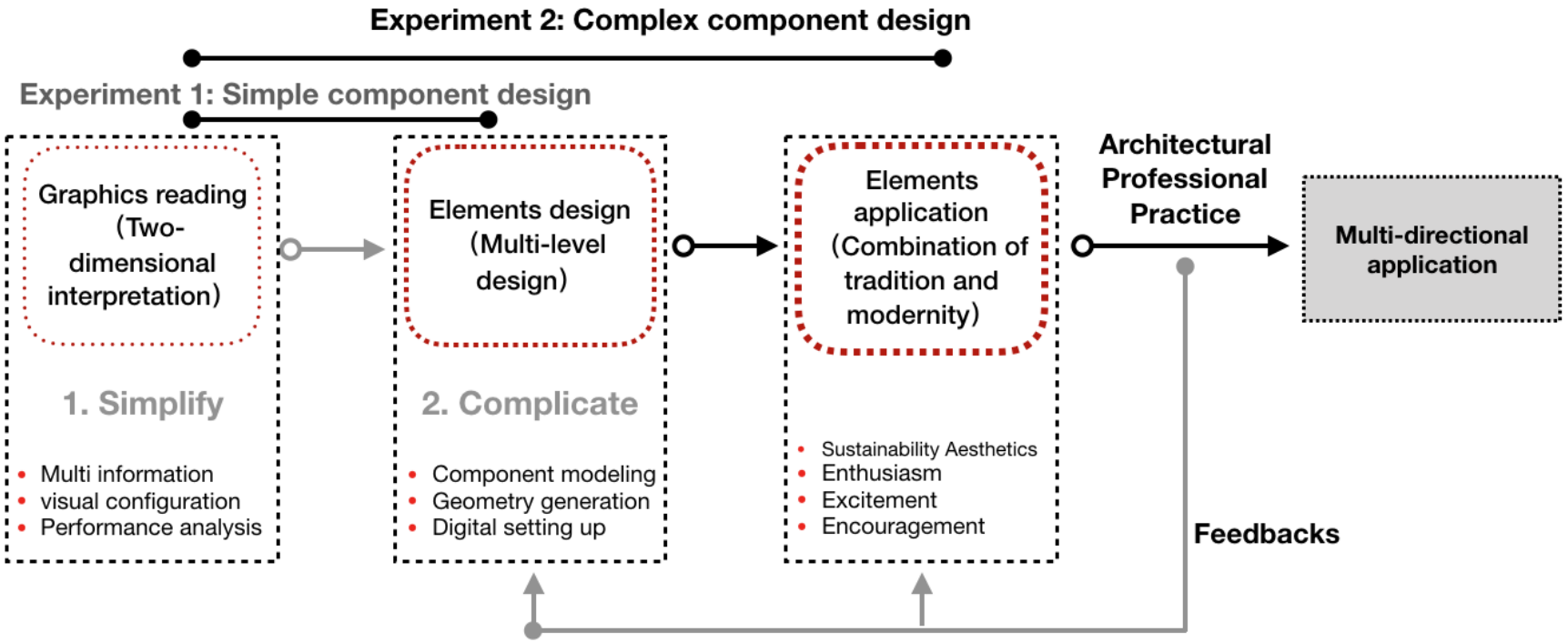


Figure 5-1 Framework for process of digital design

5.2 Digital experiment

Digital design has played an important role in architectural design in the last few decades[1, 2]. Students subscribing to the pedagogy are first introduced to digital software such as Maya as a tool to explore the logic of geometrical systems so that they can begin to consider its use for generating design concepts. The impetus for exploring design logic in the first stage is to have students gain the ability to easily capture design intent and define families of building elements.

Through the investigation of traditional patterns, we can analyze the pattern culture from the three levels of vision, logic and concept in practice. Try the visual element translation model, the behavioral logic element translation model, and the conceptual element translation model. In the extraction part of the visual elements of traditional pattern culture, the explicit semantics of the elements can be extracted, such as shape, color matching, pattern, composition, rhythm, etc., and the implicit semantics such as customs, myths, etc. Legends, religious beliefs, etc.

The extracted elements are decomposed and reorganized by digital design, the deformation and processing of pattern elements, and the deconstruction and isomorphism of imagery are used to translate traditional cultural visual elements into visual combinations that conform to the current aesthetic trend. Through the translation of this process, the display of traditional cultural elements is no longer scattered and lacking vitality, but a state of semantic and morphological connection, which realizes the integration of visual perception and cultural connotation (Figure 5-2).

The logic of the behavior composition of traditional patterns is based on people's daily behavior habits in the past. The logical translation of pattern formation needs to be simple, natural and variable.

Concepts in culture refer to the values, aesthetic preferences, and thinking patterns formed by people who have lived in the same environment for a long time. It is the core part of culture. Concepts are abstract and obscure, without concrete forms and shapes. The translation of the cultural concept of patterns is to select a set of specific cultural themes, extract the representative cultural features from them, extract the colors, lines, textures, and

semantics, and use rhythm, rhythm, symmetry, balance and other design techniques to construct the image The scene, the sense of space, time, story plot and other factors in the scene can guide users to arouse users' memory and understanding of this cultural concept and scene through the symbolic features and semantics of the product

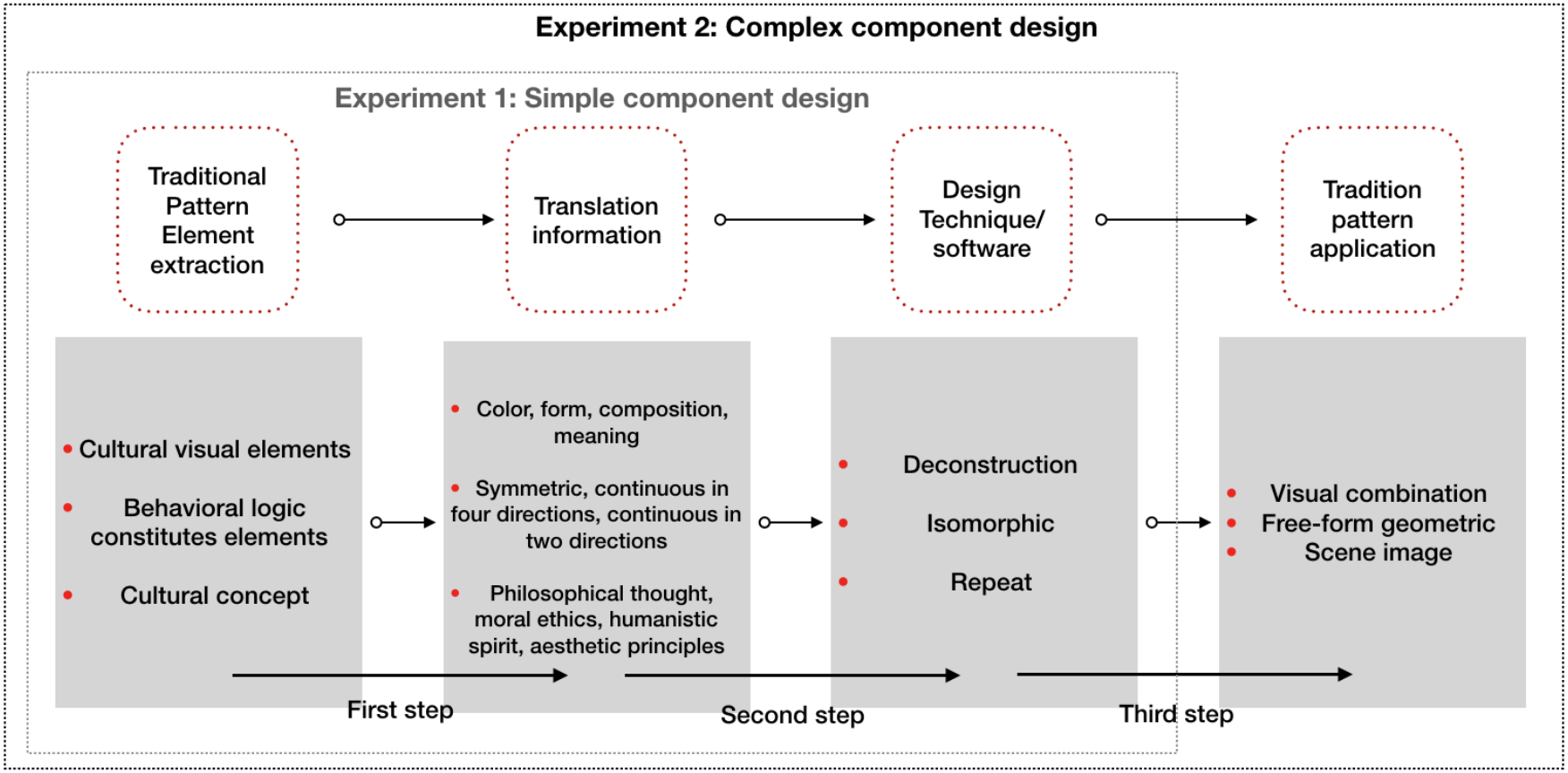


Figure 5-2 Detail framework for process of digital design

5.2.1 Experiment One—Natural beauty

The first design element comes from the natural pattern. Many ornaments were used on the stele's sides during the Northern and Southern Dynasties (420-589) due to its concise and straightforward style and a strong sense of rhythm. Single-leaf mosaic, double-mosaic mosaic, or three mosaics were arranged on both sides of the trunk to form a continuous smooth two-sided continuous ribbon pattern. The extension of the S-shaped structure from the Taiji figure forms the curve pattern, regarded as the constant and quadrangular endless patterns formed by many secondary graphical elements. The elemental composition changes slightly with different themes and locations, but the details are always ordered in a ripple curve. The complete volume of the pattern must have a dynamic curve grass and geometrical skeleton together. The attempt came from the scroll pattern in the mural.

The first step of the design is to extract the essential elements from the pattern prototype and do the curvature analysis, including intersecting relationship, tangent relationship. Make a basic element unit based on these（Figure 5-3). The second step is to aggregate the basic unit based on the pattern combination logic. From a two-dimensional perspective, it includes parallel relationships and vertical relationships. Specific commands include Duplicate, Bridge, etc. The third step is to use the commands of "Rotation", "Mirror", "Duplicate", "Scaling" to make the shapes prosperous in a system by graphic language analysis. The fourth step is to develop in the three-dimensional direction, and the design can be extended in the XYZ direction with "Mirror" and other commands（Figure 5-4). The entire software operation process can obtain basic command output through Maya's Mel language, and form a certain connection between the most used commands and the possible shapes for future statistics and shape estimation（Figure 5-5).

Based on the basic element extraction method, 2-3 basic pattern units can be selected, and then repeated iterative operations, including the deformation of single graphics, and the Mirror and Rotate of the iterated graphics. It will produce unlimited patterns with the infinite superposition of elements, and the structure reaches the extreme. The practice concept also comes from Flower and grass patterns according to the rules of the growth of flowers combined with patterns and the basic Pattern extracted from natural flowers. Get inspiration from the petals, the mosaic, the stamen, and the traditional Chinese painted patterns. Tracing the origin, there is a genuine blood relationship between design and painting art. Abstract the objects' characteristics, use purely rational points, lines, the surface to form the beauty of

the abstract. First of all, extract the basic monomer from the growth of grass blades and curly petals' primary form and decorate it. And then form the primary motif with further modification and optimization. After the monomer obtained in the previous step with further symmetric and moving transformation, adjust each other's position and angle, resulting in the final motif. Combined with the concept "flower", the motifs are arranged according to logic. It is used to extract the styling features of the flowers. Symmetry, floral images, petal layers, set, reverse, radiation and overlap, making modelling more flexible. The interpretation and inheritance of traditional cannot be traced to simple repetition and imitation of the form. Finally, smooth the final model, compare arc-shaped lines with blocks body, showing a rounded, well-proportioned sense of hierarchy, like natural plants. The whole material is attached to metal, making the entire model pursue nature with modernity and industrial sense (Figure 5-6). Another small element experiment used the same process (Figure 5-7、Figure 5-8、Figure 5-9).

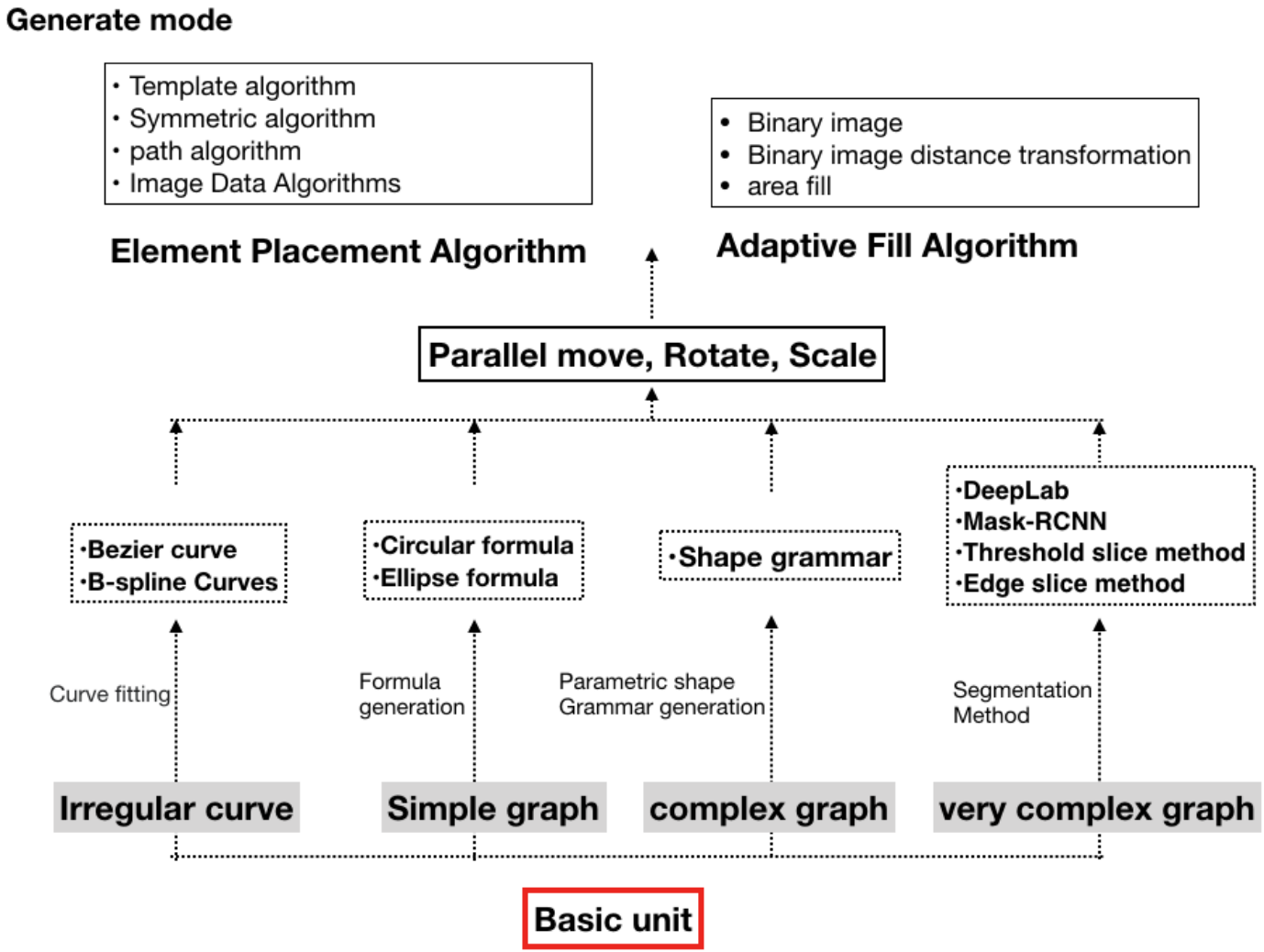


Figure 5-3 Generate mode of the basic unit

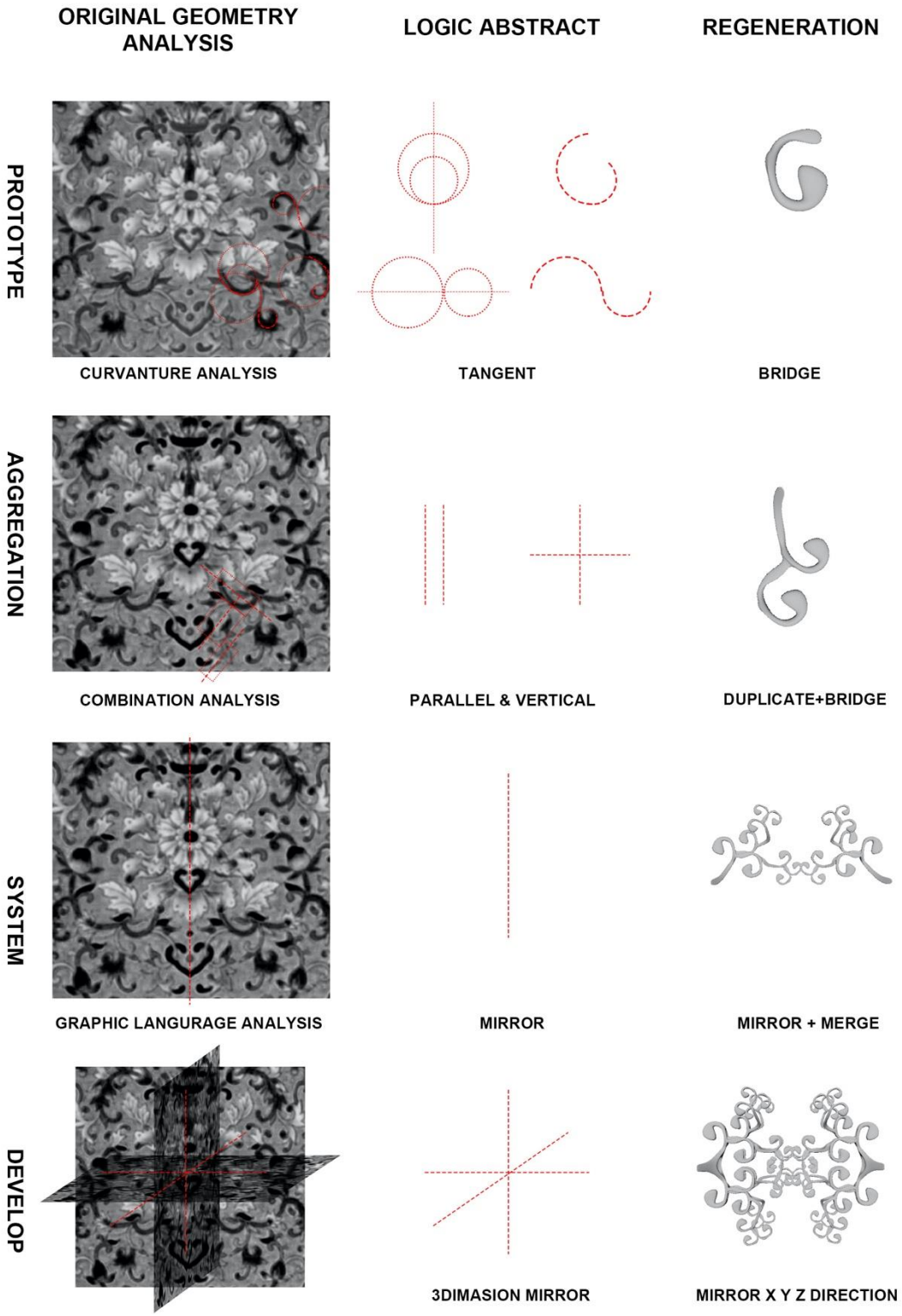


Figure 5-4 Extraction of the pattern elements

AGGREGATION

```
select -tgl _pCube77.e[80] ;
polyBridgeEdge -ch 1 -divisions 4 -twist 0 -taper 1 -curveType 0 -smoothingAngle 30 -direction 1 -sourceDirection 0
-targetDirection 0;
setAttr "polyBridgeEdge12.divisions" 0;
select -r _pCube77.e[90] ;
select -tgl _pCube77.e[40] ;
polyBridgeEdge -ch 1 -divisions 4 -twist 0 -taper 1 -curveType 0 -smoothingAngle 30 -direction 1 -sourceDirection 0
-targetDirection 0;
setAttr "polyBridgeEdge13.divisions" 0;
select -r _pCube77.e[129] ;
select -tgl _pCube77.e[57] ;
polyBridgeEdge -ch 1 -divisions 4 -twist 0 -taper 1 -curveType 0 -smoothingAngle 30 -direction 1 -sourceDirection 0
-targetDirection 0;
setAttr "polyBridgeEdge14.divisions" 0;
select -r _pCube77.e[152] ;
select -tgl _pCube77.e[70] ;
polyBridgeEdge -ch 1 -divisions 4 -twist 0 -taper 1 -curveType 0 -smoothingAngle 30 -direction 1 -sourceDirection 0
-targetDirection 0;
setAttr "polyBridgeEdge15.divisions" 0;
```

SYSTEM

```
select -r _pCube77 ;
polyMirrorFace  -cutMesh 1 -axis 0 -axisDirection 1 -mergeMode 1 -mergeThresholdType 0 -mergeThreshold 0.001
-mirrorAxis 2 -mirrorPosition 0 -smoothingAngle 30 -flipUVs 0 -ch 1 _pCube77;
setAttr "polyMirror22.axis" 1;
setAttr "polyMirror22.axis" 0;
setAttr "polyMirror22.axisDirection" 0;
setAttr "polyMirror22.mirrorAxis" 1;
setAttr "polyMirror22.mirrorPlaneCenter" -type double3 -10.100577 0.0049697 -83.63312 ;
setAttr "polyMirror22.axisDirection" 1;
setAttr "polyMirror22.mirrorPlaneCenter" -type double3 -11.624065 0.0049697 -83.63312 ;
```

DEVELOP

```
select -r _pCube77 ;
polyMirrorFace  -cutMesh 1 -axis 0 -axisDirection 1 -mergeMode 1 -mergeThresholdType 0 -mergeThreshold 0.001
-mirrorAxis 2 -mirrorPosition 0 -smoothingAngle 30 -flipUVs 0 -ch 1 _pCube77;
setAttr "polyMirror23.axis" 1;
setAttr "polyMirror23.mirrorAxis" 1;
setAttr "polyMirror23.mirrorPlaneCenter" -type double3 -10.851421 -0.236596 -83.63312 ;
select -cl  ;
select -r _pCube77 ;
polyMirrorFace  -cutMesh 1 -axis 0 -axisDirection 1 -mergeMode 1 -mergeThresholdType 0 -mergeThreshold 0.001
-mirrorAxis 2 -mirrorPosition 0 -smoothingAngle 30 -flipUVs 0 -ch 1 _pCube77;
setAttr "polyMirror24.axis" 2;
setAttr "polyMirror24.axisDirection" 0;
setAttr "polyMirror24.mirrorAxis" 1;
```

Figure 5-5 Command of extracting pattern elements

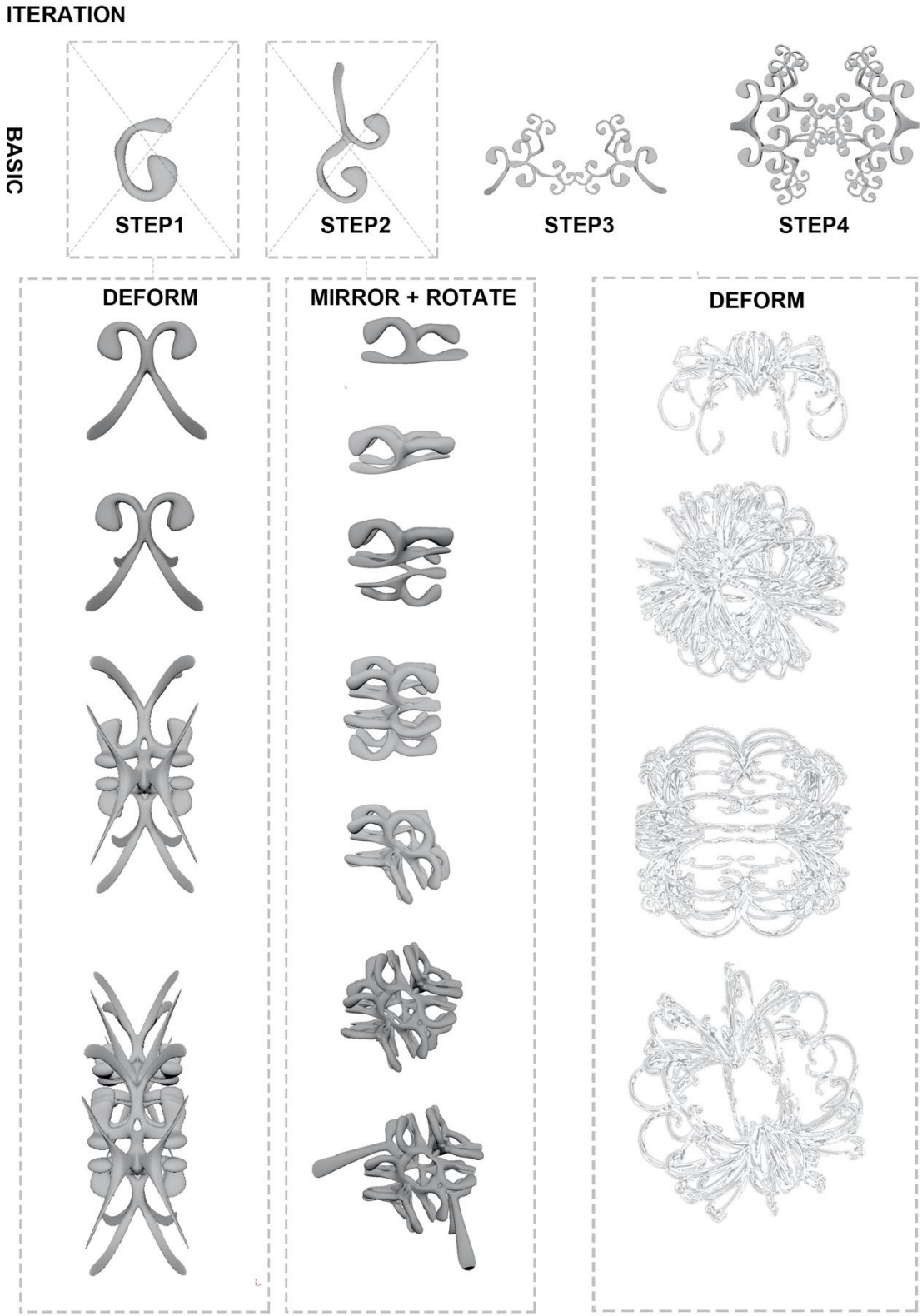


Figure 5-6 Iteration of the pattern elements

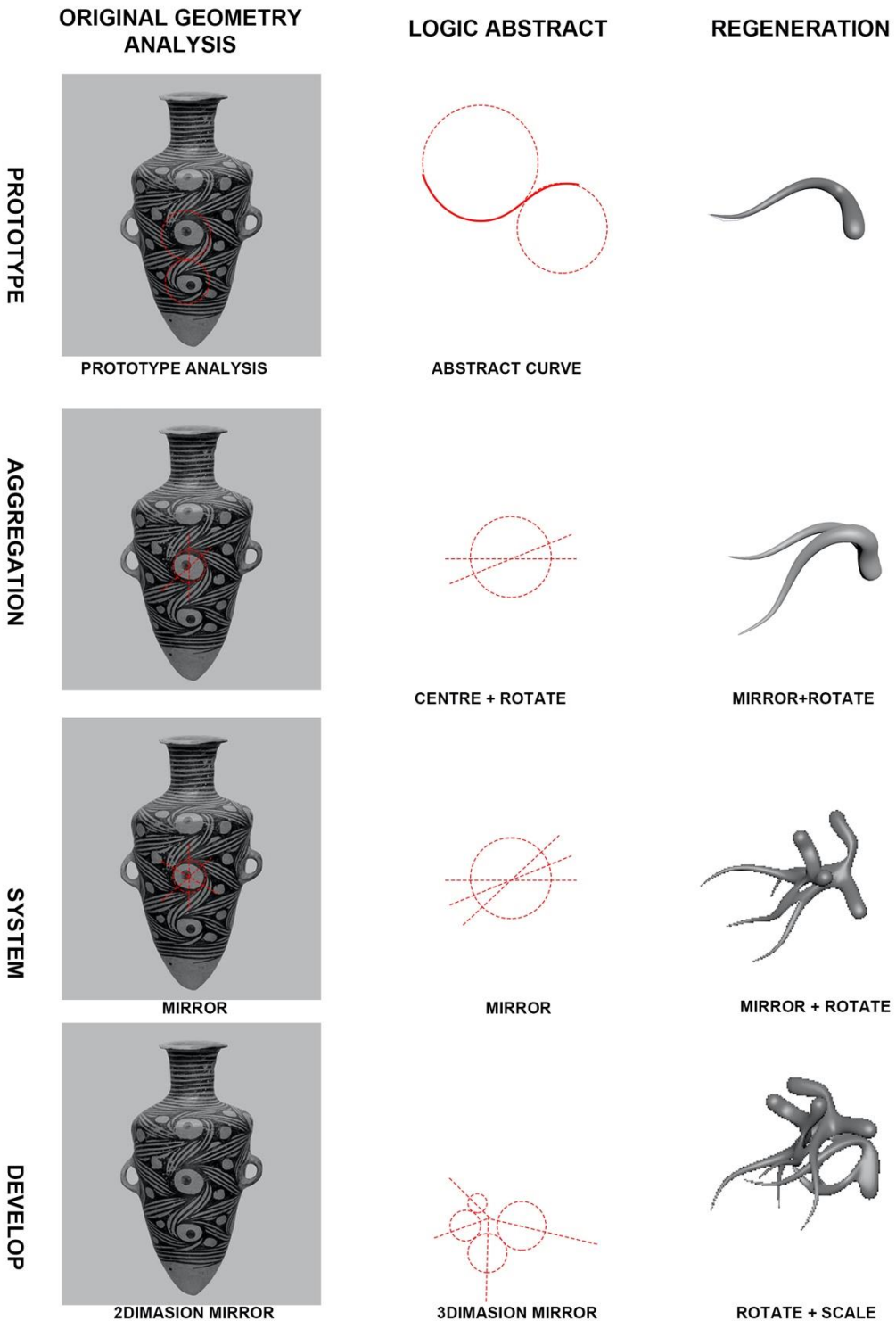


Figure 5-7 Extraction of the pattern elements

AGGREGATION

```
polyMirrorFace -cutMesh 1 -axis 0 -axisDirection 1 -mergeMode 1 -mergeThresholdType 0 -mergeThreshold 0.001
-mirrorAxis 1 -mirrorPosition 0 -smoothingAngle 30 -flipUVs 0 -ch 1 pCube41;
setAttr "polyMirror4.mirrorPlaneCenter" -type double3 -1.538297 0 0 ;
setAttr "polyMirror4.axisDirection" 0;
setAttr "polyMirror4.mirrorPlaneCenter" -type double3 0.106978 0 0 ;
setAttr "polyMirror4.mirrorPlaneRotate" -type double3 0.484363 0 0 ;
setAttr "polyMirror4.cutMesh" 0;
setAttr "polyMirror4.mirrorPlaneRotate" -type double3 0.274474 0 0 ;
select -cl  ;
select -r pCube41 ;
duplicate -rr;
```

SYSTEM

```
polyMirrorFace -cutMesh 1 -axis 0 -axisDirection 1 -mergeMode 1 -mergeThresholdType 0 -mergeThreshold 0.001
-mirrorAxis 1 -mirrorPosition 0 -smoothingAngle 30 -flipUVs 0 -ch 1 pCube43;
setAttr "polyMirror6.axisDirection" 0;
setAttr "polyMirror6.cutMesh" 0;
setAttr "polyMirror6.mirrorPlaneRotate" -type double3 0.359275 0 0 ;
setAttr "polyMirror6.mirrorPlaneRotate" -type double3 0.352468 0.0711075 -0.190805 ;
setAttr "polyMirror6.mirrorPlaneRotate" -type double3 0.0790212 0.0711075 -0.190805 ;
polyMirrorFace -cutMesh 1 -axis 0 -axisDirection 1 -mergeMode 1 -mergeThresholdType 0 -mergeThreshold 0.001
-mirrorAxis 1 -mirrorPosition 0 -smoothingAngle 30 -flipUVs 0 -ch 1 pCube44;
setAttr "polyMirror7.axisDirection" 0;
setAttr "polyMirror7.mirrorPlaneCenter" -type double3 -3.767173 0 0 ;
setAttr "polyMirror7.axisDirection" 1;
setAttr "polyMirror7.mirrorPlaneCenter" -type double3 -1.83023 0 0 ;
setAttr "polyMirror7.mergeThreshold" 1;
setAttr "polyMirror7.smoothingAngle" 38.2;
rotate -r -os -fo 0 82.754441 0 ;
rotate -r -os -fo 0 33.369029 0 ;
```

DEVELOP

```
select -r pCube61 ;
rotate -r -os -fo 0 0 27.134038 ;
select -cl  ;
select -r pCube61 ;
rotate -r -os -fo -53.627609 0 0 ;
scale -r 1.685052 1.685052 1.685052 ;
select -cl  ;
select -r pCube62 ;
duplicate -rr;
// Result: pCube63 //
move -r 0 0 -5.120366 ;
move -r 0 -2.070092 0 ;
rotate -r -os -fo 102.800056 0 0 ;
scale -r 1.339389 1.339389 1.339389 ;
```

Figure 5-8 Command of extracting pattern elements

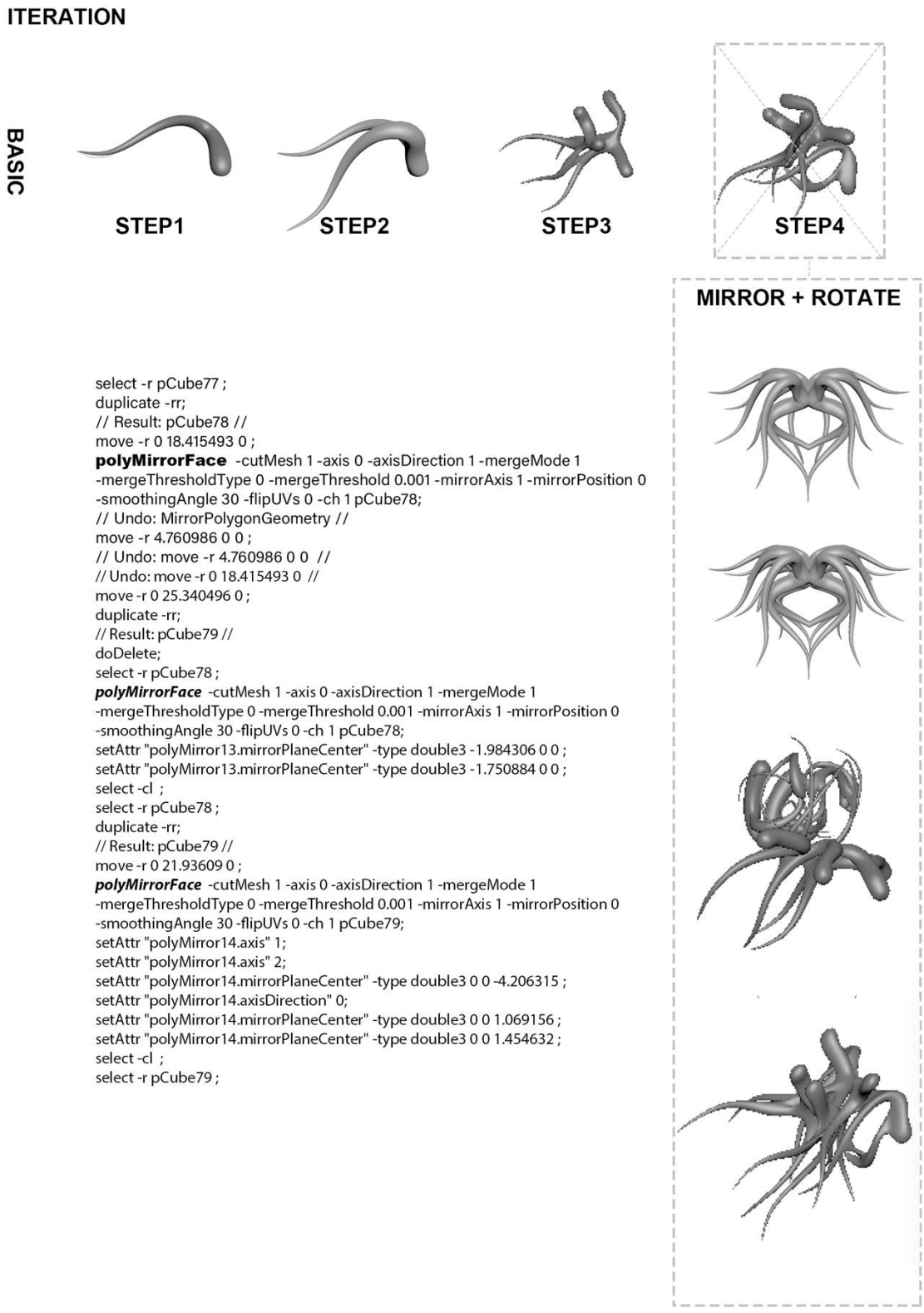


Figure 5-9 Iteration of the pattern element

5.3 Complex component practice

5.3.1 Experiment One: Scroll grass pattern

It is a model of the traditional design in floral and grass patterns. It is an exotic pattern. The scroll grass pattern in China came from the honeysuckle pattern, which was initially originated in ancient Egypt and transmitted to India via Greece. During the Eastern Han Dynasty, it was introduced into China with Indian Buddhism. After undergoing complex evolution, it eventually formed the original style in Tang (618-907). Scroll grass patterns have different names of different eras and regions. In Europe, it is called tendril decoration. In Arabia, it is called vine pattern. In China, it is called a scroll grass pattern or tangled pattern. In Japan, it is customarily called tang grass[3]. Therefore, it has specific Western characteristics and can be reanalyzed and transformed into computer programs based on Western design thinking (geometric analysis formula).

The scroll grass pattern is created by the extension of the S-shaped structure from the "Tai chi" figure. It can be regarded as the two-direction continuous and four-direction continuous patterns formed by many secondary graphical elements. With different themes and different locations, the elemental composition changes slightly, but the details are always ordered in a ripple curve. The complete volume of the pattern has a dynamic curve grass and geometrical skeleton together. When constructing geometric bones structure, they often follow the bend in the tangential or reverse concatenation. At some links, graphics are used to attract the visual focus. The characteristics of the curl pattern are the intricate beauty of plants interlacing, simplifying the elements based on repeated observation of traditional patterns, keeping the main components of the pattern unchanged, and reducing the leaves and curls into relatively large masses. Changes in parameters have a significant effect on the role of the skeleton. Like the two-direction continuous patterns, the rhythm of the graphic distribution can be summarized by the tangent of the circular curve. The whole structure is a universal framework, and many variations can be found in specific applications. Adjust the curve value and turn fixed point vertically or horizontally. The yellow dots where the curves intersect in the figure are the positioning points of the variable body. The flower shape on these points can be changed into other elements. Combine the single elements in different forms to obtain variable prototypes along with different skeleton structure. Next, use the commands of rotation, copy, scaling to make the shapes prosperous. It will produce unlimited patterns with the infinite superposition of elements. The structure reaches the extreme. The designer combined the traditional patterns and the basic shapes of flowers and plants in

nature to design the final scheme form according to the growth law. Tracing the origin, there is a natural blood relationship between design and painting art. Designers extract the unique sensory characteristics of art and then use a purely rational method: Points, lines, surfaces, and blocks to form the beauty of the abstract.

Scroll grass pattern and lotus pattern have obvious traces of historical inheritance and evolution. The development and changes of society affect people's ideological cognition, and traditional patterns as handicrafts directly carry the ideological understanding of the times. Each era has the unique characteristics of the tangled lotus pattern and scroll grass pattern. Before the Wei and Jin dynasties, plant patterns were not as popular as in the Song Dynasty. After Buddhism was preached and introduced, decorative patterns began to merge more with the patterns of exotic plants, absorbing the gorgeous characteristics of the patterns. The honeysuckle pattern is widely used. There is also a point of view that the tangled honeysuckle pattern is a combination of the characteristics of foreign patterns in the Han Dynasty cirrus cloud pattern, inheriting the continuous characteristics of the scroll grass pattern of the Southern and Northern Dynasties, presenting a smooth and elegant beauty. In the Tang Dynasty, it was influenced by the social culture at that time. The morphological characteristics of the tangled branches are famous for its full branches and leaves, rich lingering, and smooth curls. The tangled lotus is already a stylized pattern. The structural habit of the tangled branches in the Tang Dynasty is a symmetrical continuation from a central pattern to four directions, thus forming a rich and full composition. Starting from the Five Dynasties, the plane composition of flowers and plants has been enhanced, the shape of the flower head is more prominent in the details of the pattern, and the leaves have become smaller. In the Song Dynasty, with the preference of Han culture, the overall pattern became more slender and agile. The elegant rhythmic lines and geometrically constituted unit patterns formed a harmonious contrast between lines and points, movement and stillness. There is a strong sense of movement.

The inspiration for this practice came from the blue-and-white porcelain pattern. From the tangent and reverse changes in the figure, the designers extract the simple component from the growth of grass blades and the basic form. This single form is the basic structure that can derive the S-shaped dynamic form, a basic structure, which has the characteristics of being a basic copy of the continuous pattern in four directions. As such a unit form, some of the original graphics, such as the flower in the figure below, are variable bodies that can be replaced by other elements. In addition to this two-dimensional tiling arrangement order, it

can also be regularly rotated and divided according to the division of the skeleton（Figure 5-10）.

After determining the specific unit form, try to use equation substitution and digital software to assist it in the reproduction and derivation of graphics according to the set order. The graphic unit is regarded as the basic unit. When doing the reproduction calculation, the traditional pattern order is extracted as the setting (Figure 5-11).

Combine several essential elements freely to form a primary motif with further modification and optimization. After that, the final theme is generated from the primary motif with further symmetry and movement transformations, through juxtaposition, inversion, radiation, and overlap. Combine these components with existing buildings, changing the trajectory of "points" and "lines" in accordance with the original architectural form, free from the constraints of the natural way. The arc-shaped lines and body masses show a rounded, patchy, and layered sense, like flowers and grasses in nature. Attaching metal to the overall object, while pursuing nature, the design also has a sense of modernity and industrial feeling. When setting the turning trend of the specific curve of the scroll grass pattern (twisted branch pattern), the calculation formula of the Bezier curve is emphasized in the optimization of the modeling calculation. Its advantage is that it can adjust the curvature and turning degree of the entire curve by setting a fixed point. The CV curve command is used in the Maya software. Under the influence of parameter positioning, redefine the curve. In the setting of specific constituent elements, because the curly pattern is mostly S-shaped, fourth-order curves can be introduced in the setting of individual curves and optimized by formula calculations to form a perfect basic framework for dynamic development (Figure 5-12).

By adjusting the data to change the momentum of the curve, the underlying graphics will also change accordingly. On the basis of this framework, it is further deepened and strengthened to make the form further extreme, complex and rich. The original fuzzy winding curve is replaced by a simple geometric basic type, and the characteristics of the original pattern can be well maintained during the replacement process. The secondary graphic elements used on the basic skeleton graphic pattern can be replaced with a variety of choices. For example, the secondary graphics in the design practice are changed under the control of Maya's multiple commands. This change can be made in accordance with the pattern development law. This kind of control is also more possible to play and enjoy the possibility of graphic creation. The two-sided continuous curve does not have to be horizontal or vertical. In many cases, some variations will occur according to the specific application, such as the

circular two-sided continuous curve. Its logical composition is also basically similar, but slightly different in expression. Under the order of parameter guidance, the pattern is advanced from two-sided continuous to four-sided continuous, or even eight-sided continuous(Figure 5-13).

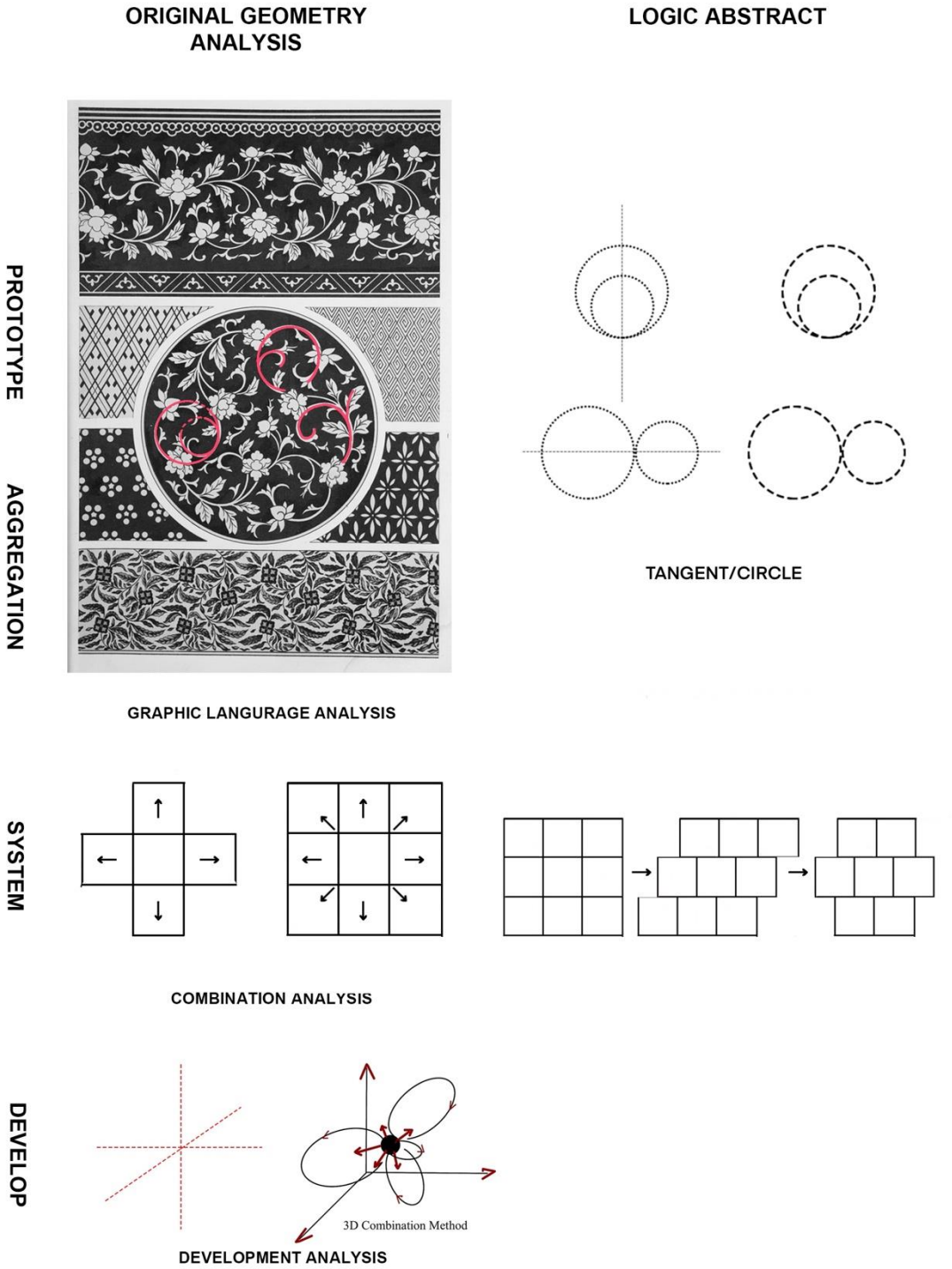


Figure 5-10 Analysis of the pattern elements

curve -d 3 -p 1.549118 0 -2.493703 -p 2.607053 0 -1.889169 -p 4.118388 0 -3.476071 -p 3.816121 0 -4.534005 -p 1.851385 0 -5.743073 -p -0.717884 0 -3.551637 -p -1.775819 0 -0.831234 -p 2.002519 0 2.644836 -p 3.589421 0 4.911839 -p 6.460957 0 8.161209 -p 6.309824 0 11.561713 -k 0 -k 0 -k 0 -k 1 -k 2 -k 3 -k 4 -k 5 -k 6 -k 7 -k 8 -k 8 -k 8 ;
CreatePolygonCube; setToolTo CreatePolyCubeCtx;
polyCube -ch on -o on -ax 0 -1 0 -w 0.906801 -h 0.604534 -d 1.284635 -cuv 4 ;
// Result: pCube1 polyCube1 //
polyExtrudeFacet -constructionHistory 1 -keepFacesTogether 1 -pvx 2.078085631 -pvy -0.05531800099 -pvz -2.682619647 -divisions 15 -twist 0 -taper 0.2069 -off 0 -thickness 0 -smoothingAngle 30 -inputCurve curve1 pCube1.f[5];
// Result: polyExtrudeFace1 //
displaySmoothness -divisionsU 3 -divisionsV 3 -pointsWire 16 -pointsShaded 4 -polygonObject 3;
select -d pCube1.f[5] ;
displaySmoothness -divisionsU 0 -divisionsV 0 -pointsWire 4 -pointsShaded 1 -polygonObject 1;

curve -d 3 -p 0.498477 0 -0.527799 -p 1.730008 0 0.117289 -p 2.316452 0 0.703732 -p 3.313406 0 0.762377 -p 4.544937 0 -0.117289 -p 6.186979 0 -3.049506 -p 5.835112 0 -5.102058 -p 0.967632 0 -7.389188 -p -0.322544 0 -6.802744 -p -2.081874 0 -4.984769 -p -2.785606 0 -1.231531 -p -2.081874 0 1.407464 -p 0.205255 0 3.811883 -p 1.495431 0 5.981723 -p 1.260853 0 8.444786 -k 0 -k 0 -k 0 -k 1 -k 2 -k 3 -k 4 -k 5 -k 6 -k 7 -k 8 -k 9 -k 10 -k 11 -k 12 -k 12 -k 12 ;
selectMode -component ;
select -r pCube1.f[59] ;
polyExtrudeFacet -constructionHistory 1 -keepFacesTogether 1 -pvx -0.702592045 -pvy -0.01088049269 -pvz -1.912731842 -divisions 15 -twist 0 -taper 0.2069 -off 0 -thickness 0 -smoothingAngle 30 -inputCurve curve2 pCube1.f[59];
// Result: polyExtrudeFace2 //
displaySmoothness -divisionsU 3 -divisionsV 3 -pointsWire 16 -pointsShaded 4 -polygonObject 3;
displaySmoothness -divisionsU 0 -divisionsV 0 -pointsWire 4 -pointsShaded 1 -polygonObject 1;
select -cl ;

CreatePolygonCube;
setToolTo CreatePolyCubeCtx;
polyCube -ch on -o on -ax 0 -1 0 -w 0.511767 -h 0.625493 -d 0.56863 -cuv 4 ;// Result: pCube2 polyCube1 //
polyExtrudeFacet -constructionHistory 1 -keepFacesTogether 1 -pvx 3.549503655 -pvy -0.09398807735 -pvz 3.224588859 -divisions 10 -twist 0 -taper 0.2069 -off 0 -thickness 0 -smoothingAngle 30 -inputCurve curve1 pCube2.f[5];
// Result: polyExtrudeFace1 //
polyUnite -ch 1 -mergeUVSets 1 -centerPivot -name curve1 curve1 curve2 pCube1 pCube2;
// Result: curve3 polyUnite1 //
polySplitRing -ch on -splitType 1 -weight 0.413476 -smoothingAngle 30 -fixQuads 1 -insertWithEdgeFlow 0 ; // Result: polySplitRing1 //
polyBridgeFaces; select -d curve3.f[148] curve3.f[175] ;select -add curve3.e[354] curve3.e[356] curve3.e[358:359] ;
polyBridgeEdge -ch 1 -divisions 0 -twist 0 -taper 1 -curveType 1 -smoothingAngle 0 -direction 0 -sourceDirection 0 -targetDirection 0;
// Result: polyBridgeEdge1 //

CreatePolygonCube; setToolTo CreatePolyCubeCtx;
polyCube -ch on -o on -ax 0 -1 0 -w 0.585392 -h 0.450302 -d 0.495332 -cuv 4 ;// Result: pCube1 polyCube1 //
polyExtrudeFacet -constructionHistory 1 -keepFacesTogether 1 -pvx -7.693661134 -pvy 0.2251508626 -pvz -5.62051468 -divisions 10 -twist 0 -taper 0.2069 -off 0 -thickness 0 -smoothingAngle 30 -inputCurve curve1 pCube1.f[4];
// Result: polyExtrudeFace1 //
polyUnite -ch 1 -mergeUVSets 1 -centerPivot -name curve3 curve3 pCube1;
// Result: curve4 polyUnite1 //
polyBridgeFaces;
select -d curve4.f[106] curve4.f[227] ;
polyBridgeEdge -ch 1 -divisions 0 -twist 0 -taper 1 -curveType 1 -smoothingAngle 0 -direction 0 -sourceDirection 0 -targetDirection 0;
// Result: polyBridgeEdge1 //
displaySmoothness -divisionsU 3 -divisionsV 3 -pointsWire 16 -pointsShaded 4 -polygonObject 3;
select -cl ;

Figure 5-11 Extraction of the pattern elements

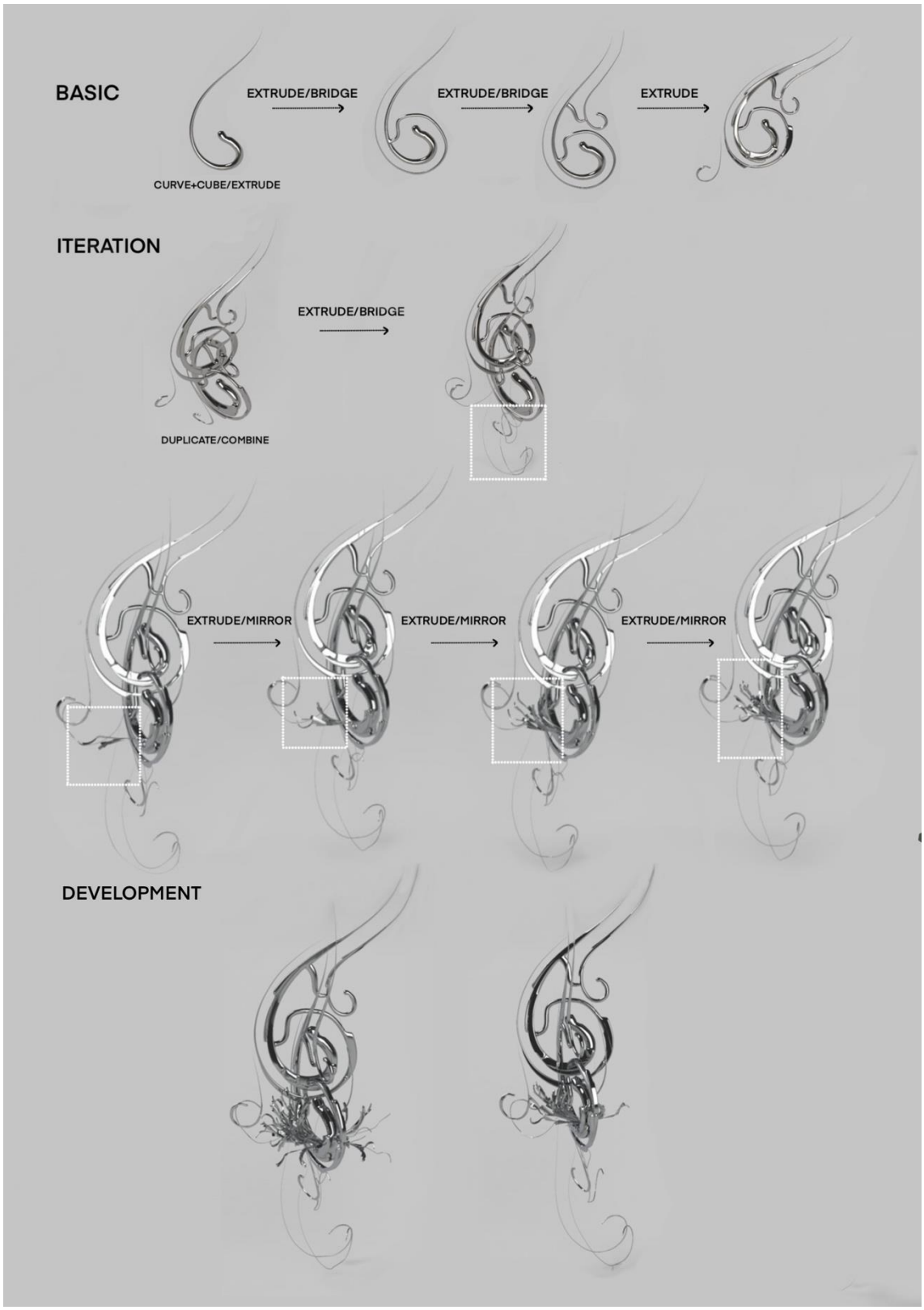


Figure 5-12 Iteration of scroll grass pattern (1)

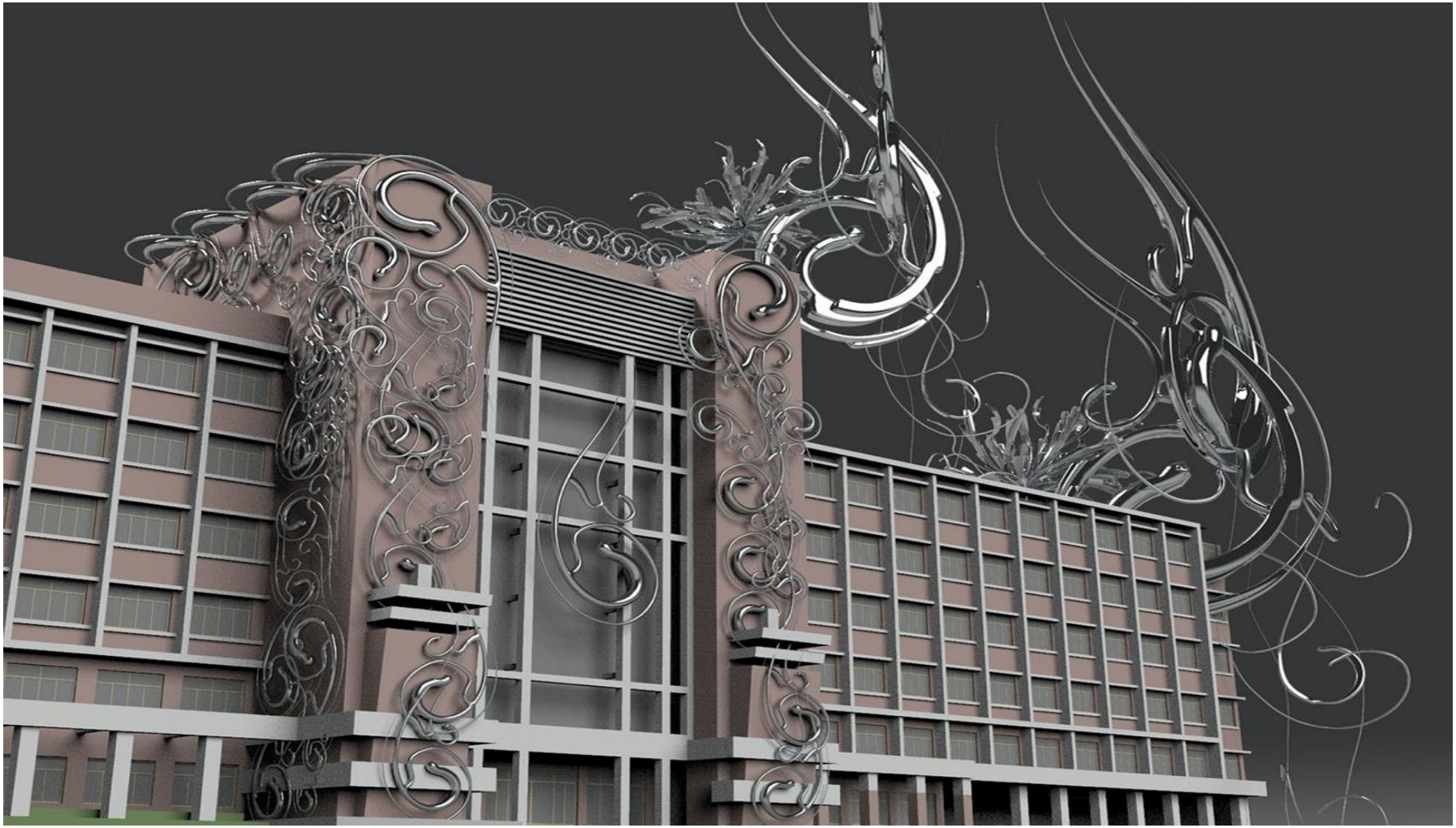


Figure 5-13 Application of scroll grass pattern (2)

5.3.2 Experiment two: Geometric Pattern

Geometric patterns are a broad category of traditional patterns, appearing in the primitive society of China. It first appeared in the decoration of painted pottery in the Neolithic era. At that time, the ancestors mainly decorated their painted pottery with abstract figures, such as dots, lines, and blocks. Since then, many pattern elements on ceramics have been used, thus laying the foundation for the development of primitive art. "Various curved patterns, straight patterns, water patterns, swirling patterns, triangle patterns, silver tooth patterns, cloud patterns are abstract traditional geometric patterns, which are the characteristics of Neolithic pottery patterns" [4].

There are two main originations of geometric patterns: First, people hunted for a living during the primitive society. At that time, their thoughts were immature. Most of the contacts were animals and plants. Simple abstract ideas were formed by observing some natural things. It originated from the intellectual evolution of pictographic to geometric. In addition to the inevitable trend of abstraction caused by the pictographic mode of "observing objects and taking images," there are also reasons from decoration and craftsmanship. Due to the intentional or unintentional smearing at that time, the shapes formed by those points, lines, and faces slowly showed a symmetrical and regular rhythm, which gradually evolved into triangles, rhombuses, squares, and other patterns. The curves slowly evolved into patterns, such as circles and wavy lines, which are all geometric figures we are familiar with. In art, we call them geometric patterns. Second, in primitive society, people knew how to use fabrics for heating and to protect themselves with wicker weaves. The orderly beauty is shown by wicker weaving and braiding slowly formed the style of geometric decoration.

1. Cloud and thunder pattern:

Cloud and thunder pattern is a kind of geometric pattern. It is a linear form of rotation. When the linear form turns into a circle, it is called a cloud pattern. When the linear form turns into a square, it is called a thunder pattern. Although the structure of the cloud and thunder pattern also have different expression styles on various materials, they are generally expressed as photographing, bas-relief, painting, and engraving. There are also two primary forms of presentation. One is a two-direction continuous composition decorated at the central position of the container. The other is a ground pattern that fills the gaps. The overall shape is different, including diamonds, triangles, rectangles, etc. to present a full and gorgeous effect.

The inspiration for this project is a Ruyi Cloud pattern in the Qianlong period of the Qing Dynasty. The first step is to extract the pattern elements. The Yunruyi pattern is composed of

a lock-shaped pattern in an orderly manner. The individual element is generated in a discontinuous, independent, and unique manner: From the morphological point of view, its biggest feature is that the tail has a larger curvature and a higher degree of bending (Figure 5-14 and 5-15).

The basic pattern of the figure is obtained through the interpretation of the pattern and obtained by the extrude command of the Maya software. Through the interpretation of constitutional logic, its aggregation relationship is a multi-directional extension. Therefore, in the redesign process, by determining the center, the design is continuously extended to make it a system and finally develop in multiple dimensions (Figure 5-16).

In the final combination mode, two elements are combined by copying, rotating, mirroring, and merging, then the size and thickness are adjusted. Finally, it forms a central symmetric and balanced model. In terms of material selection, the metal material is given to each monomer and the final assembly, which offers a sense of luster and smoothness, showing great visual tension pleasure (Figure 5-17,5-18,5-19).

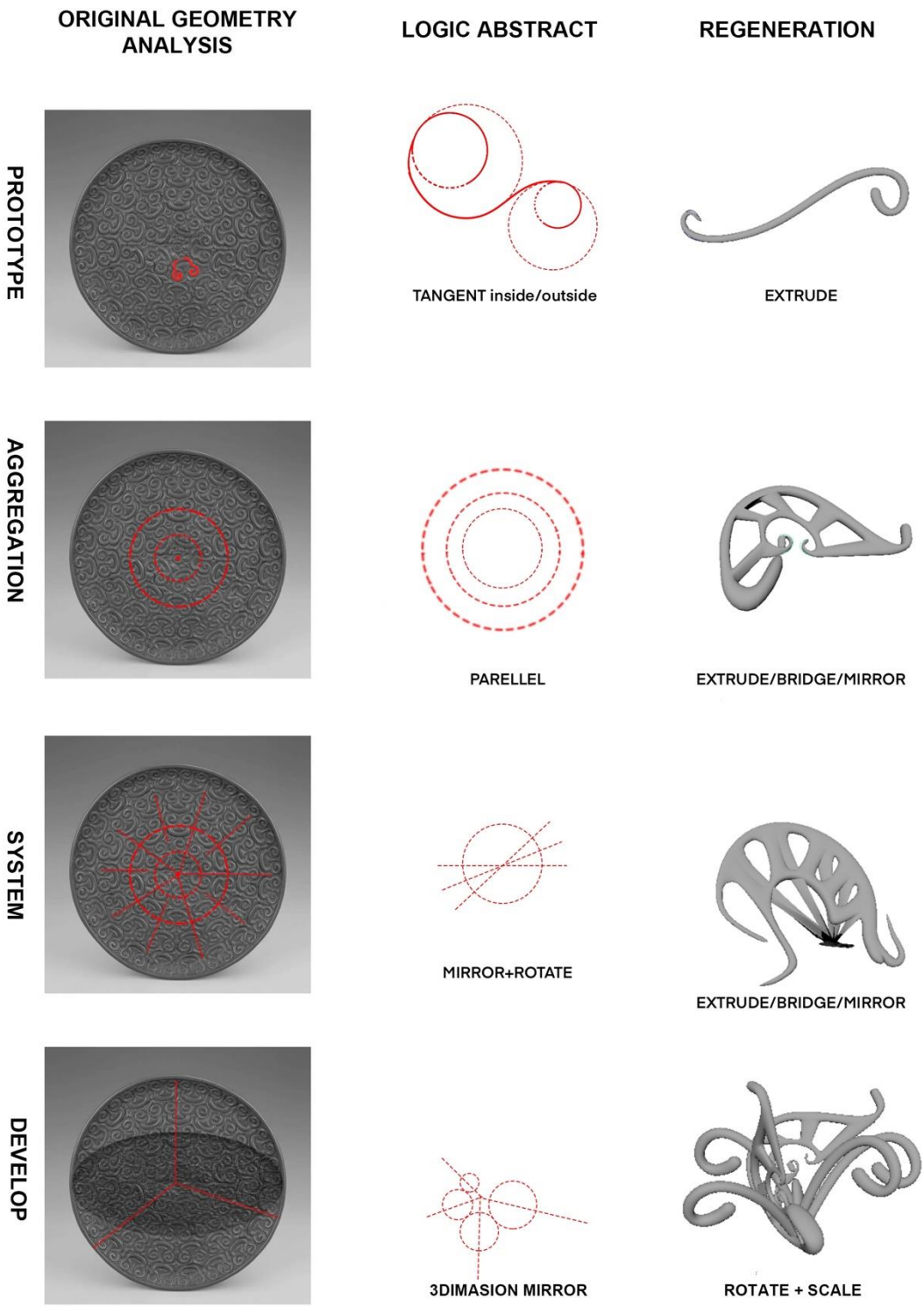


Figure 5-14 Extraction of the pattern elements

COMMAND

PROTOTYPE

```
curve -d 3 -p 0 5.118483 0 -p 0 5.722749 -0.63981 -p 0 6.540284 -0.533175 -p 0 6.646919 0.14218 -p 0 6.042654 1.030806 -p 0
4.407583 0.995261 -p 0 3.874408 0.07109 -p 0 4.265403 -0.888626 -p 0 3.092417 -1.492891 -p 0 -0.106635 -2.879147 -p 0
-3.625592 -2.345972 -p 0 -3.021327 -0.7109 -p 0 -0.35545 -0.177725 -p 0 -0.995261 -1.706161 -p 0 -1.741706 -1.528436 -p 0
-1.528436 -0.995261 -p 0 -1.172986 -1.137441 -k 0 -k 0 -k 0 -k 1 -k 2 -k 3 -k 4 -k 5 -k 6 -k 7 -k 8 -k 9 -k 10 -k 11 -k 12 -k 13 -k 14 -k 14
-k 14 ;
select -r curve1 ; rebuildCurve -ch 1 -rpo 1 -rt 0 -end 1 -kr 0 -kcp 0 -kep 1 -kt 0 -s 15 -d 3 -tol 0.0001 "curve1"; // Result: curve1 //
CreatePolygonCube; setToolTo CreatePolyCubeCtx; polyCube -ch on -o on -ax 1 0 0 -w 0.116081 -h 0.084059 -d 0.0960674 -cuv 4 ;
// Result: pCube1 polyCube1 // select -af polyCube1 ;
polyExtrudeFacet -constructionHistory 1 -keepFacesTogether 1 -pvx -0.004997018237 -pvy 4.572698809 -pvz -1.317327453
-divisions 20 -twist 0 -taper 0.4 -off 0 -thickness 0 -smoothingAngle 30 -inputCurve curve1  pCube1.f[4];
// Result: polyExtrudeFace1 //
select -d pCube1.f[4] ;
displaySmoothness -divisionsU 3 -divisionsV 3 -pointsWire 16 -pointsShaded 4 -polygonObject 3;
```

AGGREGATION

```
curve -d 3 -p; select -d curve1 ;
curve -d 3 -p; select -r curve1 curve2 ;
rebuildCurve -ch 1// // Result: curve1 // rebuildCurve -ch 1// Result: curve2 //
CreatePolygonCube; setToolTo CreatePolyCubeCtx;
polyCube -ch on -o on -ax 1 0 0 -w 0.0325629 -h 0.0169327 -d 0.0273529 -cuv 4 ;
// Result: pCube1 polyCube1 //  select -af polyCube1 ;
CreatePolygonCube; setToolTo CreatePolyCubeCtx;
polyCube -ch on -o on -ax 1 0 0 -w 0.0299579 -h 0.0156302 -d 0.0286554 -cuv 4 ; // Result: pCube2 polyCube2 //
polyExtrudeFacet -constructionHistory 1 -keepFacesTogether 1 -pvx -0.0002482886719 -pvy 4.607590886 -pvz -1.227056069
-divisions 15 -twist 0 -taper 0.8 -off 0 -thickness 0 -smoothingAngle 30 -inputCurve curve1  pCube1.f[2]; // Result:
polyExtrudeFace1 //
polyBridgeFaces;
select -d pCube3.f[60] pCube3.f[91] ;
select -add pCube3.e[278] pCube3.e[280] pCube3.e[282:283] ;
polySplitRing -ch on -splitType 1 -weight 0.935724 -smoothingAngle 30 -fixQuads 1 -insertWithEdgeFlow 0 ; // Result:
polySplitRing3 //
polyExtrudeFacet -constructionHistory 1 -keepFacesTogether 1 -pvx 5.763443187e-05 -pvy 4.212551117 -pvz -1.201197922
-divisions 15 -twist 0 -taper 0.8 -off 0 -thickness 0 -smoothingAngle 30 pCube3.f[58:59] pCube3.f[90:91] pCube3.f[142]
pCube3.f[144] pCube3.f[148];
// Result: polyExtrudeFace3 //
polyExtrudeFacet -constructionHistory 1 -keepFacesTogether 1 -pvx 5.763443187e-05 -pvy 4.231440783 -pvz -1.19049865
-divisions 1 -twist 0 -taper 0.8 -off 0 -thickness 0 -smoothingAngle 30 pCube3.f[58] pCube3.f[91];
// Result: polyExtrudeFace5 //
setAttr "polyExtrudeFace5.localTranslate" -type double3 0 0 0.0385909 ;
polyBridgeFaces;
select -d pCube3.f[55] pCube3.f[91] ;
polyBridgeEdge -ch 1 -divisions 0 -twist 0 -taper 1 -curveType 1 -smoothingAngle 0 -direction 0 -sourceDirection 0
-targetDirection 0;
// Result: polyBridgeEdge4 //
select -r pCube3.f[53] ;
select -tgl pCube3.f[91] ;
performPolyBridgeEdge 0;
polySplitRing -ch on -splitType 1 -weight 0.0700177 -smoothingAngle 30 -fixQuads 1 -insertWithEdgeFlow 0 ;// Result:
polySplitRing5 //
polySplitRing -ch on -splitType 1 -weight 0.940566 -smoothingAngle 30 -fixQuads 1 -insertWithEdgeFlow 0 ;// Result:
polySplitRing6 //
polySplitRing -ch on -splitType 1 -weight 0.0876746 -smoothingAngle 30 -fixQuads 1 -insertWithEdgeFlow 0 ;// Result:
polySplitRing7 //
polySplitRing -ch on -splitType 1 -weight 0.871415 -smoothingAngle 30 -fixQuads 1 -insertWithEdgeFlow 0 ;// Result:
polySplitRing8 //
polySplitRing -ch on -splitType 1 -weight 0.113872 -smoothingAngle 30 -fixQuads 1 -insertWithEdgeFlow 0 ;// Result:
polySplitRing9 //
polySplitRing -ch on -splitType 1 -weight 0.853937 -smoothingAngle 30 -fixQuads 1 -insertWithEdgeFlow 0 ;// Result:
polySplitRing10 // select -d pCube3.e[870] pCube3.e[872] pCube3.e[874:875] ;
displaySmoothness -divisionsU 3 -divisionsV 3 -pointsWire 16 -pointsShaded 4 -polygonObject 3;
```

Figure 5-15 Command of extracting pattern elements

COMMAND

SYSTEM DEVELOP

```
CreateNURBSCircle; circle -c 0 0 0 -nr 0 0 1 -sw 360 -r 1 -d 3 -ut 0 -tol 0.0001 -s 8 -ch 1; objectMoveCommand;
select -cl  ;
CreateNURBSCircle; circle -c 0 0 0 -nr 0 0 1 -sw 360 -r 1 -d 3 -ut 0 -tol 0.0001 -s 8 -ch 1; objectMoveCommand;

detachCurve -ch 1 -cos on -rpo 1 nurbsCircle2.ep[1] nurbsCircle2.ep[7];
// detachedCurve1 nurbsCircle2 detachCurve1 //
select -r detachedCurve1 ;
duplicate -rr;// Result: nurbsCircle3 //

CreatePolygonCube; setToolTo CreatePolyCubeCtx;
CreatePolygonCube; setToolTo CreatePolyCubeCtx;
setToolTo CreatePolyCubeCtx; polyCube -ch on -o on -ax 0 0 1 -w 0.113833 -h 0.114719 -d 0.158538 -cuv 4 ;

// pCube5 polyCube4 //
select -af polyCube4 ;
polyExtrudeFacet -constructionHistory 1 -keepFacesTogether 1 -pvx 0.02683362386 -pvy 1.153931779 -pvz -0.6777695144
-divisions 15 -twist 0 -taper 0.5 -off 0 -thickness 0 -smoothingAngle 30 -inputCurve nurbsCircle2  pCube5.f[1];
// polyExtrudeFace6 //
displaySmoothness -divisionsU 3 -divisionsV 3 -pointsWire 16 -pointsShaded 4 -polygonObject 3;

polyExtrudeFacet -constructionHistory 1 -keepFacesTogether 1 -pvx -0.06265311909 -pvy 0.5833750469 -pvz -0.8093756533
-divisions 15 -twist 0 -taper 0.5 -off 0 -thickness 0 -smoothingAngle 30 -inputCurve nurbsCircle3  pCube6.f[1];
// polyExtrudeFace7 //
displaySmoothness -divisionsU 3 -divisionsV 3 -pointsWire 16 -pointsShaded 4 -polygonObject 3;

polyBridgeEdge -ch 1 -divisions 0 -twist 0 -taper 1 -curveType 1 -smoothingAngle 0 -direction 0 -sourceDirection 0
-targetDirection 0;
// polyBridgeEdge6 //
hilite polyBridgeEdge6 pCube7.e[17] pCube7.e[32] pCube7.e[46:47] pCube7.e[195] pCube7.e[225] pCube7.e[239:240] ;

polyBridgeFaces;
select -d pCube7.f[9] pCube7.f[105] ;
polyBridgeEdge -ch 1 -divisions 0 -twist 0 -taper 1 -curveType 1 -smoothingAngle 0 -direction 0 -sourceDirection 0
-targetDirection 0;
// polyBridgeEdge7 //
select -r pCube7.f[7] ;
select -tgl pCube7.f[102] ;
BridgeEdge;


// polyExtrudeFace8 //
setAttr "polyExtrudeFace8.localTranslate" -type double3 0 0 0.0429736 ;
setAttr "polyExtrudeFace8.divisions" 1;
setAttr "polyExtrudeFace8.localTranslate" -type double3 0 0 0.335255 ;
select -cl  ;
polyExtrudeFacet -constructionHistory 1 -keepFacesTogether 1 -pvx 0.03428225778 -pvy
```

Figure 5-16 Command of extracting pattern elements

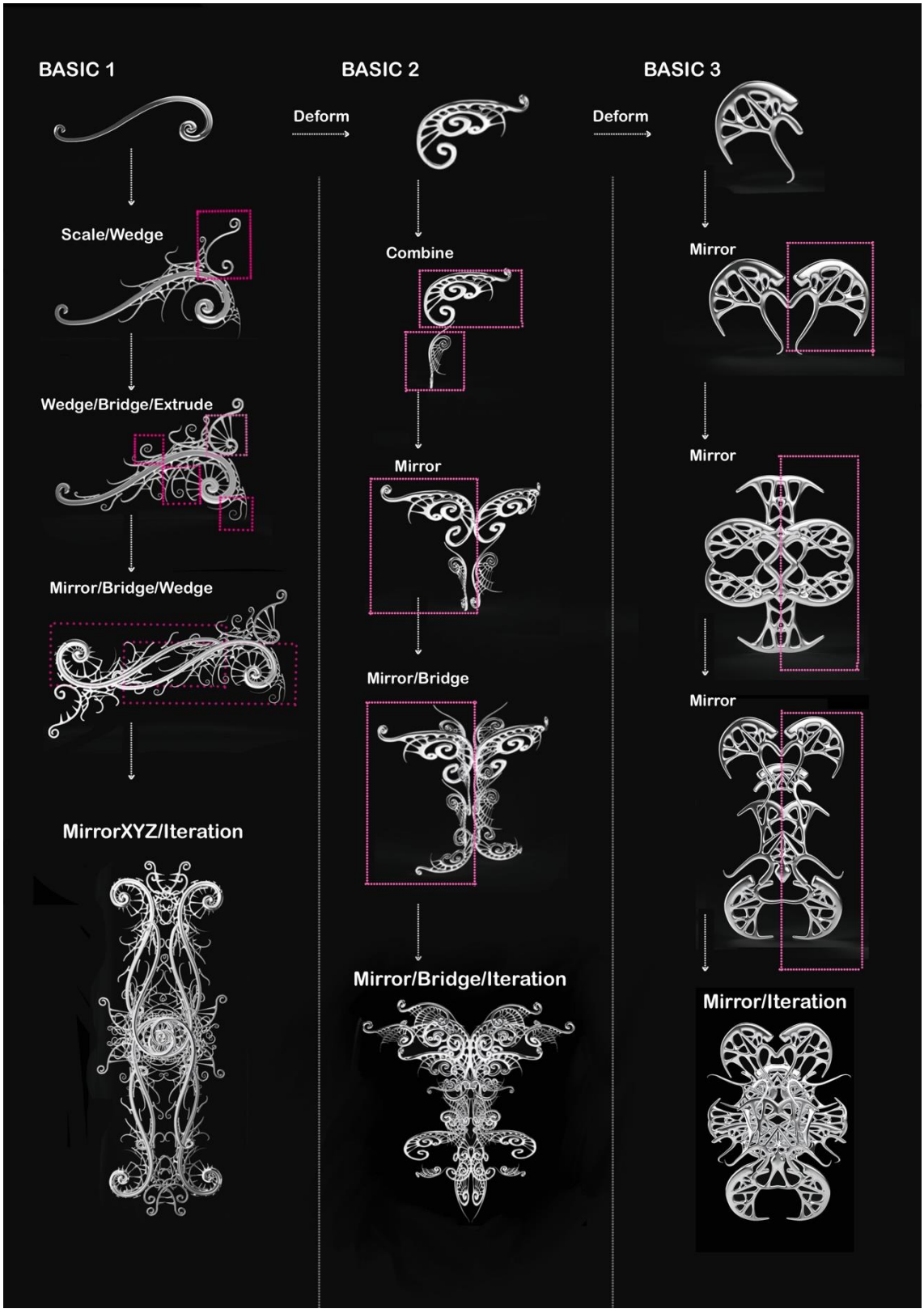


Figure 5-17 Iteration of the pattern element (1)

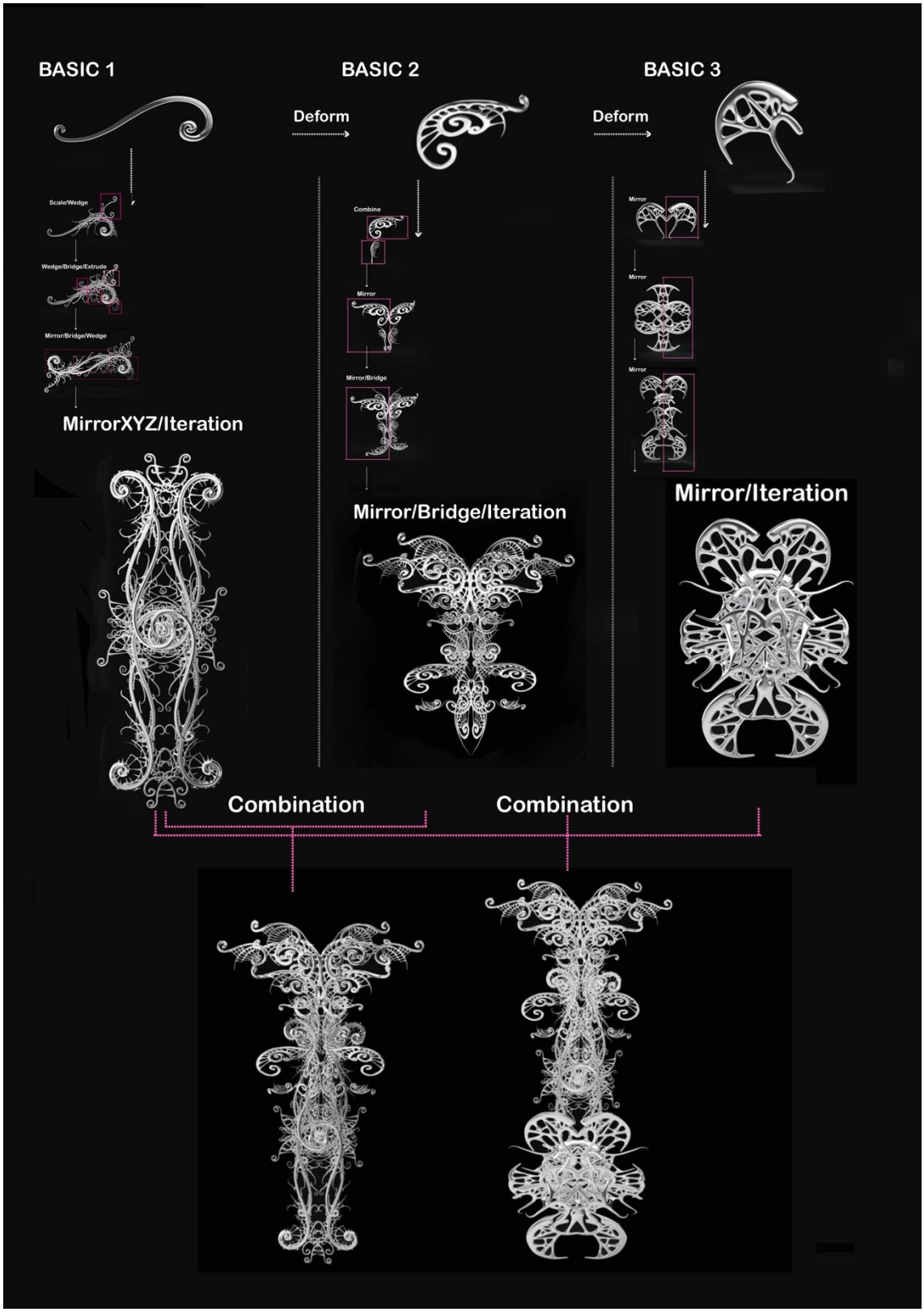


Figure 5-18 Iteration of the pattern element (2)

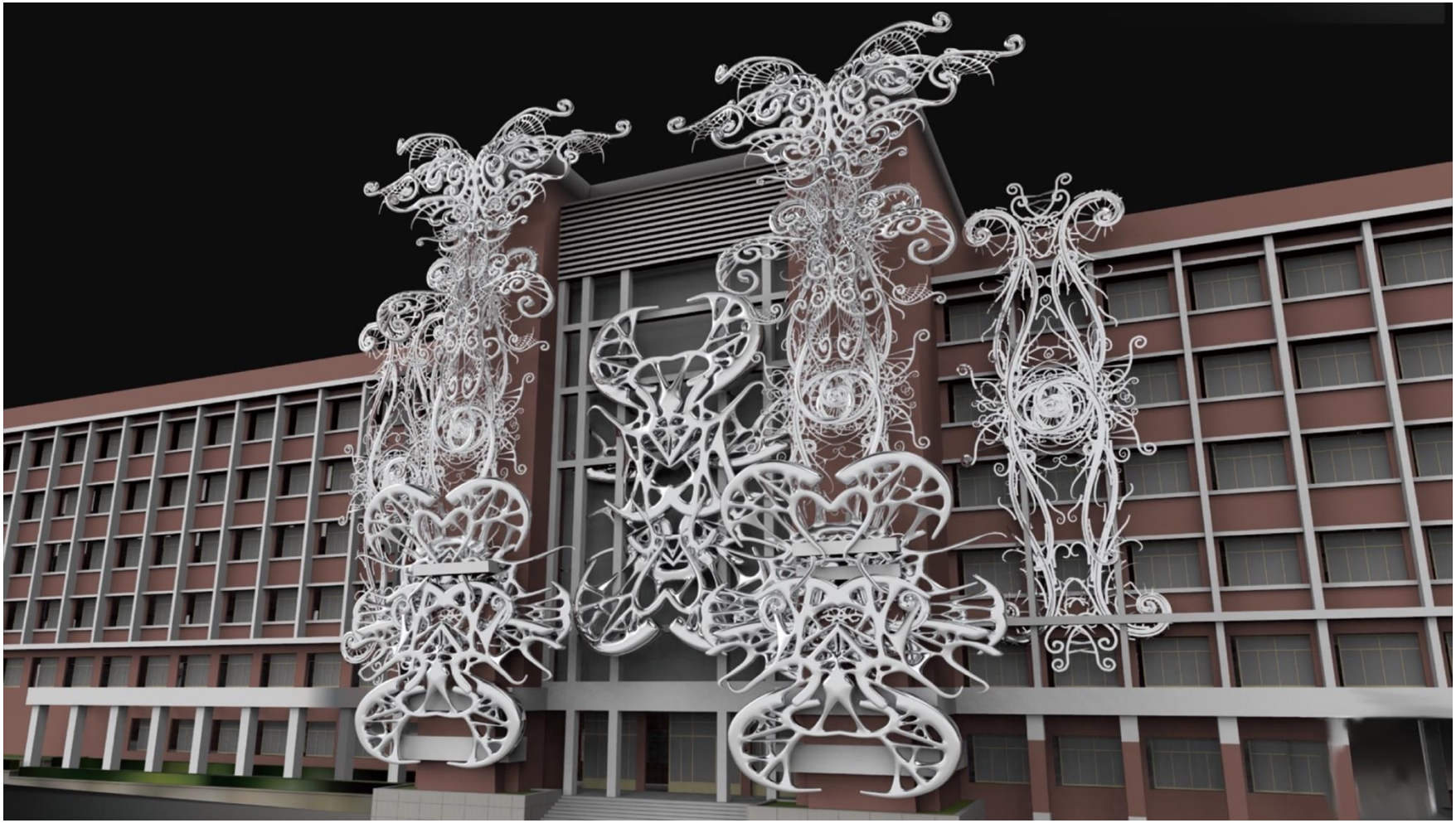


Figure 5-19 Application of cloud pattern

5.4 The conclusion of digital design experiments

Pattern graphic design belongs to the field of art design and is often regarded as a field that depends on the right hemisphere. Digital thinking belongs to the left hemisphere of scientific rationality. They are "the front and back of a coin", one that emphasizes rationalization, and one that emphasizes the perceptual visual experience. The course abandoned the original planar application of 2D graphics, encouraged students to use digital software for multiple forms of experiments. It not only broadens the application of traditional pattern but also promotes designers to deepen the concept of "shape". Russian painter Wassily Kandinsky claimed, "The final abstract expression of every art is number. Mathematical analysis and processing of painting have enabled the art of painting to rise from perceptual to rational, from general skills to scientific or quasi-scientific status"[5]. This kind of mathematics and geometry knowledge can better explain graphic aesthetics. The more time students spend exploring the logic of the things, the more they will get and reuse.

In terms of design, advanced digital technology and sculpting software has changed the designer's original scope of practice and thinking method, optimized the designer's understanding and insight, and become a medium that reflects human complexity thinking. Complexity is an integration of an aesthetic desire. A tightly controlled technique is required to form transformative surfaces that incorporate distinctly different topological features, the results are potentially chaotic. Negotiations and restraining of the visual opulence of these compositions are operations that require exuberance. It represents a mutation of regeneration in the digital design process. These experimental practices brought novel sustainability and critical thinking concepts into their design processes.

The target group of the course is the students in the sophomore year, who are not limited by a fixed thinking mode. Students can have more precise insights and a deeper understanding of new concepts. The whole process integrates the use of an aesthetic sensibility concomitant with highly developed design ability. It is a systematic thinking logic to prevent the effects of habitual processes. Students should realize that design equals energy, enthusiasm, excitement, and inspiration. To cultivate personal aesthetic ability from the elementary stage is the sustainability of education and learning.

This novel pedagogical framework explores the complete cycle of architectural design. It represents a methodical approach to "cells to organ, organs to systems, systems to new speciation", provides students with the necessary technical skills. Furthermore, it creates an experimental practice platform on which students can explore and critically apply digital technology in order to push the limits of sustainability in both the traditional culture and design education. It is a good starting point for inheriting traditional elements and finding new ideas for the design of architectural shapes. The designer tried to find new ideas for the architectural shape design, not only the reconstruction of existing design methods, but also the prediction of design methods and architectural forms that may emerge in the future.

Reference

1. Leach, N., Digital morphogenesis. Architectural Design, 2009. 79(1): p. 32-37.
2. Hensel, M., A. Menges, and M. Weinstock, Emergence: morphogenetic design strategies. 2004: Wiley-Academy Chichester.
3. Yali, W., The Simple Comparison between Chinese and Japanese Scroll Grass Pattern [J]. Art and Design, 2009. 11.
4. Li, Z., The path of beauty: A study of Chinese aesthetics. 1994.
5. Xu, W., Drawing in the Digital Age: An Observational Method for Artists and Animators. 2012: John Wiley & Sons.

Chapter 6 Discussion and quantitative analysis

6.1 Introduction

After describing the basic concepts of traditional Chinese patterns and analyzing the way of composition; based on these analyses, operate in digital software. This chapter focuses on the analysis around the process. First, it analyzes and describes the recruitment information of the units designed by 316 and the 784-questionnaire survey. The empirical analysis proved the necessity of digital design in the learning process. 153 of the 784 participants participated in the course. Based on feedback, it proved that the combination of digital design and traditional patterns can create structural thinking for design inspiration. Major efforts have been made to promote the inheritance and attention of traditional patterns.

Traditional tools like sketching, physical-modeling, and hand making modeling are embraced in the foundational levels [1]. Sketching: a way to capture and record new ideas. The way to show the deep meaning of design [2]. Physical modeling: a way of design communication. It is the stage of the conceptual idea modeling [2]. Digital methodologies and tools would be enhancing certain capabilities of generative and performative processes, changing the process and rhythm of traditional design[3, 4]. They should be popularized after developing a certain set of skills of one-to-one physical making where a sense of tectonic resolution, scale, and spatial experience is cultivated as a basis of design thinking with computer tools [1].

The proliferation of computational tools has led to a fundamental transformation in architectural pedagogy [5], especially the use of technology in design. Set up digital technology software courses in the architecture curriculum, whether they are integrated within the design studio, or stand-alone courses, which will reshape the education system. It is also a balance of software learning and using [6]. This issue has prompted diverse opinions among design educators, as some use technology whereas others are against it [7]. Digital tools positively affect the creative behaviors of designers. It possibly more appeals the students and designers from the standpoint of boosting their design creativity [8], which is defined as the capacity to produce numerous ideas with the highest level of originality [9]. In design studies, creativity has been recognized as one of the main cognitive activities [10], the starting point of design [11, 12]. Some educators think traditional design techniques will provide the most direct link between the hands and brain. The result of using technical software is simply to attract viewers with seducing graphics and shapes [13]. After learning software, students are just obsessed with good-looking shapes, and the design itself will lose creativity and connotation [14].

6.2 Results before participation

6.2.1 Research One: Profession

The data statistics of software requirements in information recruitment indicate professionals' expectations for the future, and the response far exceeds the author's original expectations. From the 316 online information around China, the answers were analyzed to find out the following.

- Computer Applications requirements in Architectural Profession Fields

Architectural design is a comprehensive act, which includes concept planning in the early stage, design expression in the middle stage, and design performance in the later stage. So, the architect should be a worker with comprehensive ability. In the application requirements, the design software requirements are divided into six catalogs: 2D design tools, 3D design tools, building information model software, image rendering software, post-graphics processing software, and professional analysis software. It is found that 16 percent of the software requirements are 2D design tools, 33 percent are 3D design tools. Then the post-graphics processing tools accounted for 40 percent. Building information model software is 4 percent, the same as rendering tools. In the end, professional analysis is only 3 percent (Figure 6-1).

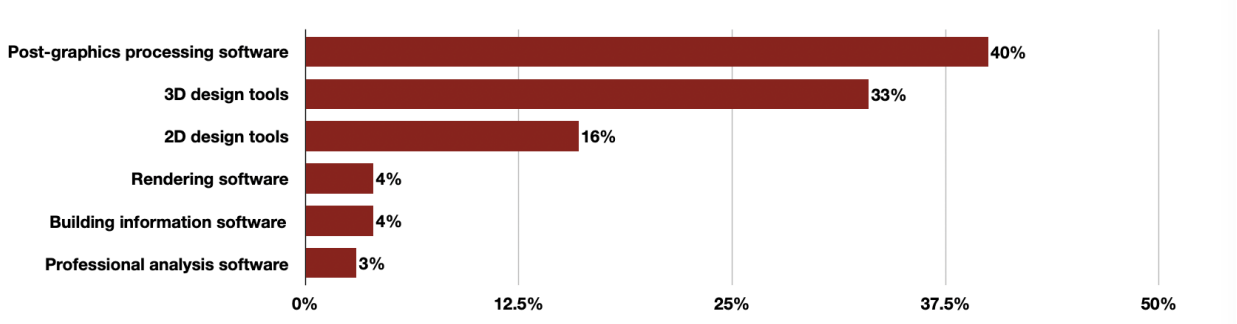


Figure 6-1 Requirements of techniques from the recruitments

- The Most Used Computer Application (Software)

The architectural profession field covered in the survey contains Junior Architect, Intermediate Architect, Senior Architect, Interior Designer, Assistant, Internship. In statistics, for traditional software, the requirement probability has reached 100 percent. Of the 316 companies counted, only four from Beijing and Shanghai did not make the requirements for the software. The demand for digital software is already as high as 69 percent. Only 31percent of companies consider digital techniques and software unnecessary (Figure 6-2).

Almost 98 percent and 79 percent of the companies are required to working with traditional software A and B. Followed by, there is the graphics processing software. From the figure, the requirements for skilled manipulation of digital applications are increasing. Digital software A is required by 66.139 percent, Digital software B by 23.101 percent and Digital software C 14.241 percent. Some companies that focus on digital and parametric design also require an applicant to be proficient with Digital software D. It's about 3.481 percent. Architecture rendering software is used by 18.354 percent, 11.392 percent, and 3.481 percent. Nearly 20 percent of companies expect candidates could use Building Information Modeling

software as well as 22.468 percent for Office software. Finally, about 0.3 percent, only one or two design firms have requirements for more professional and directional software-professional analysis software. The analysis shows that the company's requirements for digital software are increasing, regardless of technical capabilities or software types (Figure 6-3).

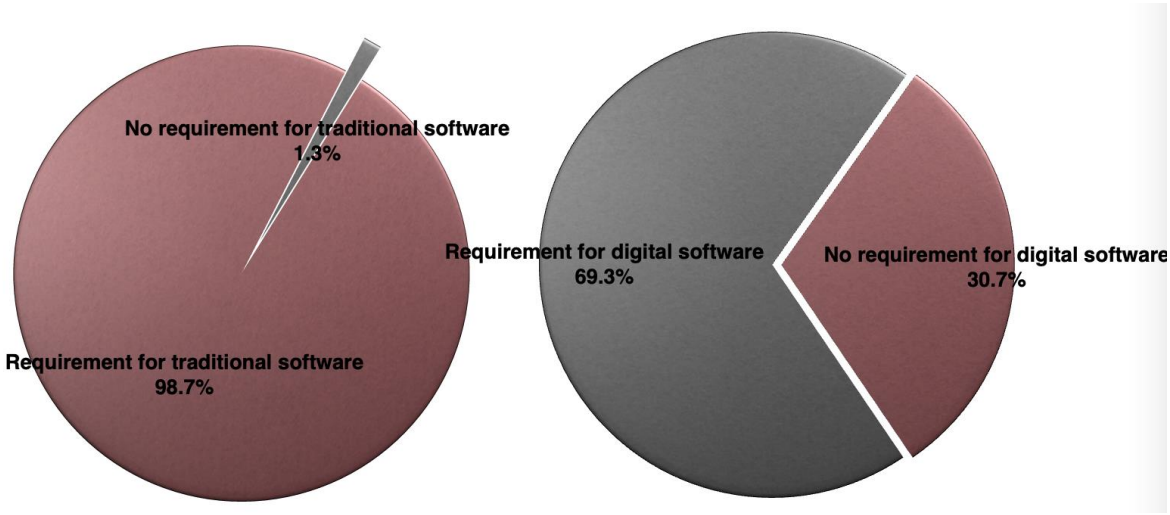


Figure 6-2 Requirements for traditional software and digital software from companies

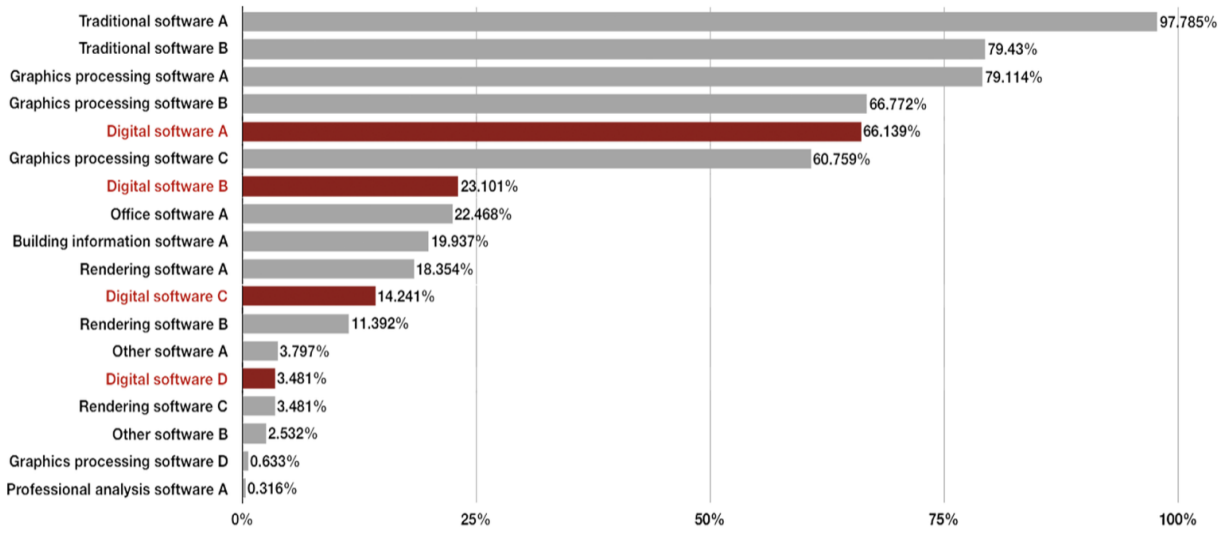


Figure 6-3 Requirement for digital software

6.2.2 Research Two: Academic

A total of 784 anonymous questionnaires were collected, including respondents from nearly 15 universities in Beijing, Shanghai, Shandong, Zhejiang, Sichuan, and Hebei. All the

questionnaires covered architecture students of all grades. Among them, 37.37 percent of the questionnaire respondents are in the elementary stage with a total of 293 students, 31.38 percent are in the development stage with a total of 246 students, and 12.88 percent of them are master students. The remaining respondents included 11.1 percent of the respondents are designers and architects who have already worked, 6.25 percent final year students, and 1.02 percent doctoral students (Figure 6-4).

For all the following figures:

"1-2Y" instead of Elementary stage students (Freshman year, Sophomore year)

"3-4Y" instead of Development stage students (Junior year, Senior year)

"5Y" instead of Mastery stage students (Final year)

"M" instead of Master students

"D" instead of Doctoral students

"P" instead of Practitioners who have already worked including designers and architects

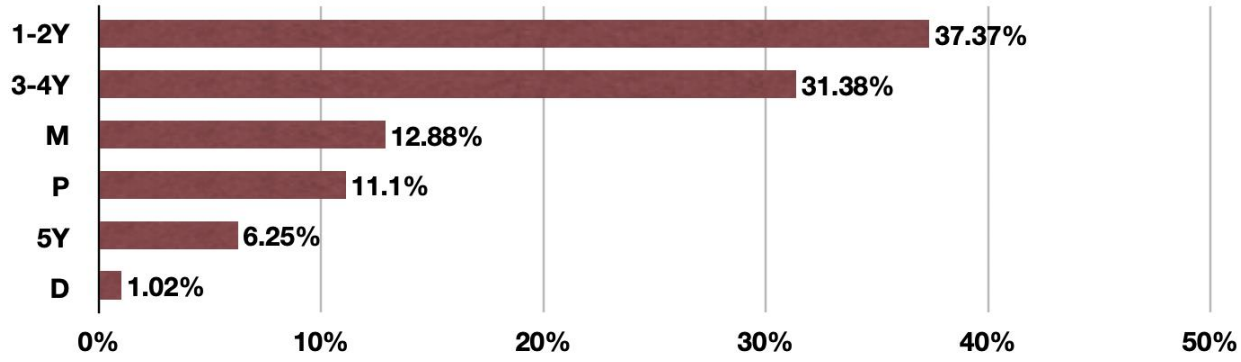


Figure 6-4 The proportion of respondents to the questionnaires

- Mastery of digital software

In all questionnaires, 61.48 percent of the participants did not know how to use digital software, they just knew about them. And 33.93 percent of the participants have a certain foundation and can operate them easily. If software creators are 100 percent proficient in software, then users in this segment have only 30 percent mastery of the software. Only 4 percent of those who are proficient in using and mastering the software and their knowledge of software is 50 percent. 0.89 percent of respondents think they are proficient in digital software (Figure 6-5).

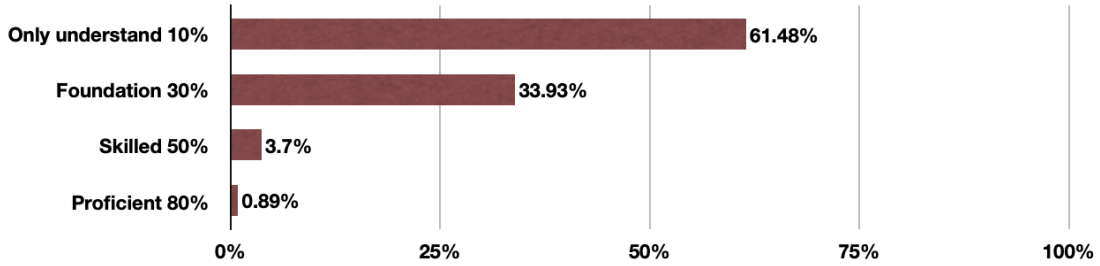


Figure 6-5 Mastery of the digital software

Through the cross-matrix analysis, we study the mastery of software at different grades, because there are not many surveyors who are proficient in digital software, so we removed this item during cross-analysis. It can be concluded that among the participants, 86.35 percent of the students in the elementary stage don't have any knowledge of software, 13.31 percent of them have some basic knowledge of the software. These two parts accounted for 99.66 percent of the total in the lower grade students; for the development stage students, more than half of them do not know how to use the digital software, and 44.49 percent of them master 30 percent of software operations, total accounted for 96.33 percent. It indicates that in Chinese universities, digital software courses are not popularized, and not every university has its arrangements. The software mastery rate of master students and doctoral students is also very low. 51.49 percent of the master students surveyed do not use digital software, and 39.6 percent have a certain foundation. The proportion of these two parts in the surveyed doctoral students is 50 percent and 37.5 percent. The rate of mastery of digital software among the practitioners surveyed has improved, with 48.28 percent having a certain foundation, while 10.34 percent are skilled in using digital modeling software. If the entire research phase is divided into two parts, the undergraduate study phase is one stage, and the master, doctoral, and work phases are counted as another stage. Most of the students at the undergraduate level stay on the level of less software mastery. However, as the grade increases, the degree of mastery will increase. At another stage, the degree of mastery is relatively average. From the overall data, the degree of mastery at skilled 50 percent has been continuously increasing (Figure 6-6).

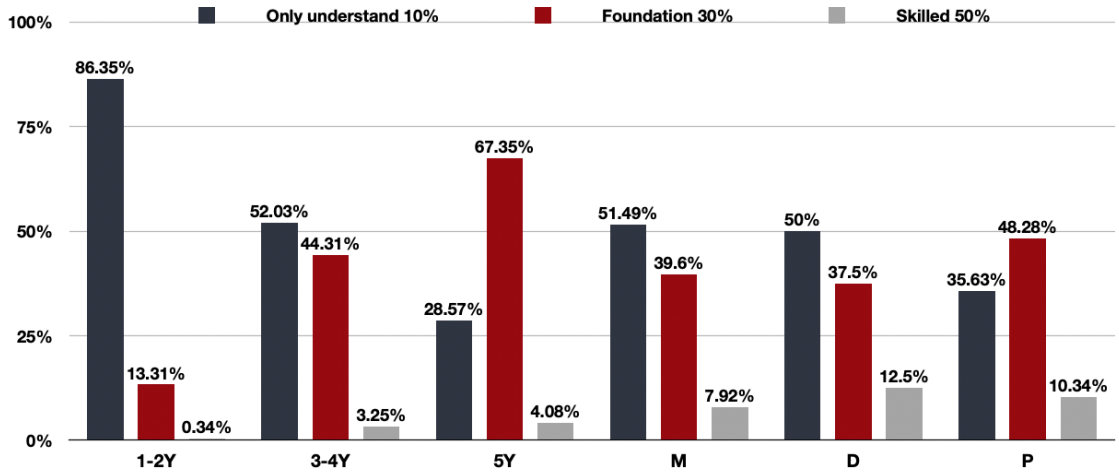


Figure 6-6 Mastery of software in different grades

- The period of mastering and learning digital software

At present, Chinese architecture students are expected to learn the digital technique. Except for 21.43 percent of participants who have never been learned digital software, most of them are in the first two years of the university, accounting for 42.09 percent; another 28.7 percent of the participants start learning in the third and fourth grades. The time to start learning is earlier (Figure 6-7).

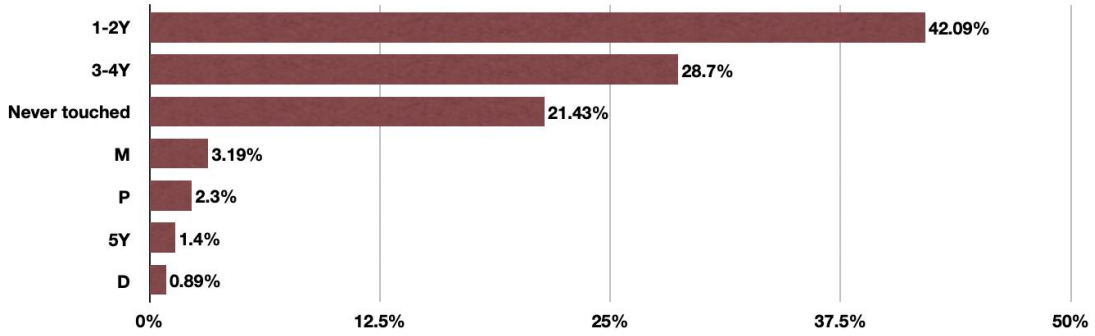


Figure 6-7 Time to start learning digital software

Through cross-data analysis, it can be seen that starting to learn digital software in the elementary stage has a higher degree of mastery than during master or doctoral studies. Of all those who are skilled or proficient in digital software, 44.83 percent and 85.71 percent of learners start in the first two years. And Investigators who have studied since the third and

fourth grades also stand for a high proportion in this part, 44.83 percent and 14.29 percent. Software users who learn early have a higher degree of mastery (Figure 6-8).

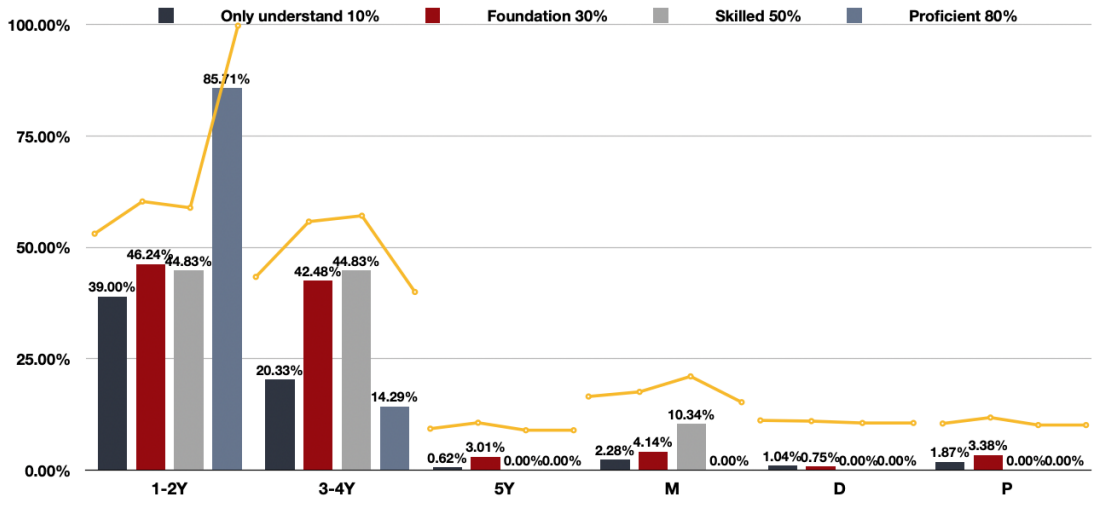


Figure 6-8 The degree of proficiency in learning software at different times

- The purpose of learning digital software

This item for the purpose of learning digital software is a multiple-choice question. Through survey data statistics, it can be found that the answers focus on career development need, field development trend, and school curriculum, which account for 66.58 percent, 46.43 percent, and 44.64 percent respectively. Personal interest is approximately 39.03 percent while the peripheral influence is 24.23 percent. This shows that learners and educators have noticed the trend of digitalization (Figure 6-9).

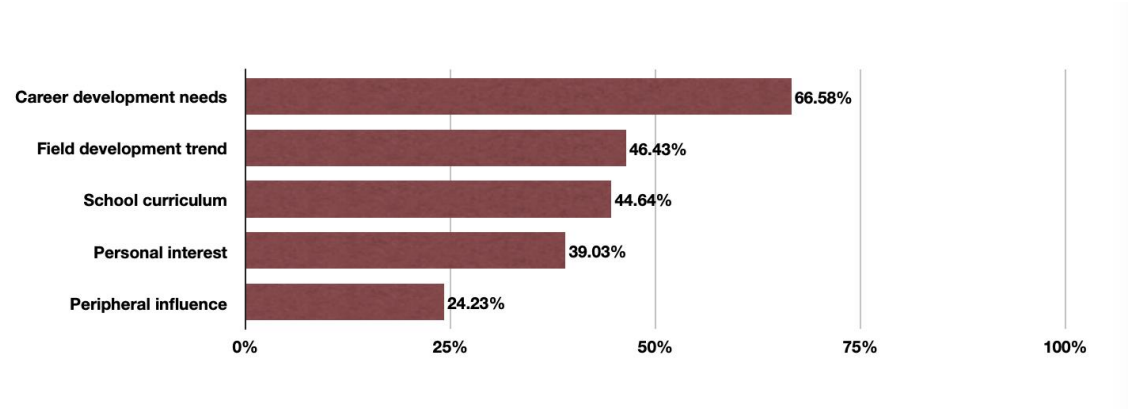


Figure 6-9 The purpose to learning digital software (Multiple choice)

- The main way to learn digital software

There are various ways to learn digital software, including active learning and passive learning. In active learning, personal self-study accounts for 83.04 percent, more than half. Participation in online classes and tutorial classes accounts for 35.59 percent, while interest groups account for 8.29 percent. Passive learning is a curriculum program, which accounts for 32.37 percent. The other 4.85 percent of students use other methods, such as learning through video. But all are active learning. As shown by data, most students are eager to learn (Figure 6-10).

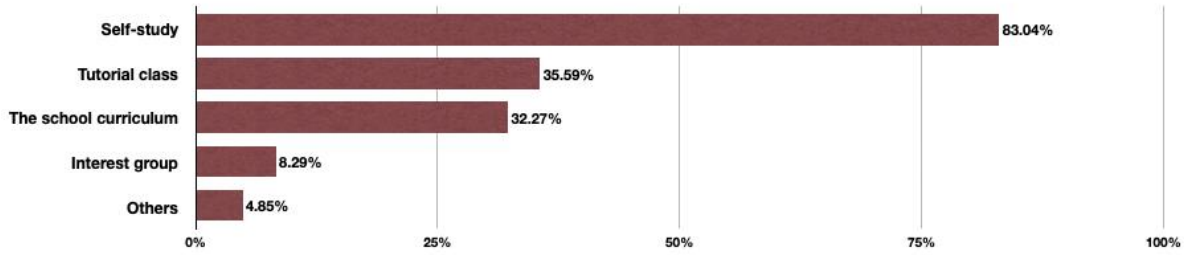


Figure 6-10 The main way to learn digital software (Multiple choice)

For different learners, self-study accounts for most of the proportion. Students in the elementary stage account for 84.85 percent, 83.56 percent in the development stage, 90.01 percent in the final year stage, 76 percent in master students, and all the doctoral students choose self-study as the main way to learn (multiple choice). Even 89.89 percent of the people who have already worked study by themselves. Tutorial class including network classes and physical classed is the second choice for each grade learner. The data are 43.33 percent in the elementary stage, 39.11 percent in the development stage, 45.45 percent in the mastery stage. 36 percent and 14.29 percent for the master students and doctoral students. The third choice is the school curriculum. One more finding through the data. practitioner is still learning through tutorial class and interest groups. All of these are active learning behaviors. All of these indirectly shows that digital software has a certain necessity in the work, and education has not been well popularized (Figure 6-11).

- Utilization of the digital software

All survey questionnaires indicate that digital software is mainly used during university study, with the proportions being 21.68 percent in the freshman year, 41.45 percent in the sophomore year, 40.05 percent in the junior year, 29.72 percent in the senior year, and 16.71 percent in the fifth year. The percentages of practical and scientific research work in master and doctoral degrees study were 16.71 percent and 6.38 percent, respectively. Digital

software usage at work is 20.41 percent (Figure 6-12). Digital software can be used in multiple stages throughout the whole design process, including the design preliminary deliberation, interim design expression, post-design performance. Among the multiple choices in the questionnaires, their proportions were 46.43percent, 57.02 percent and 61.73 percent (Figure 6-13).

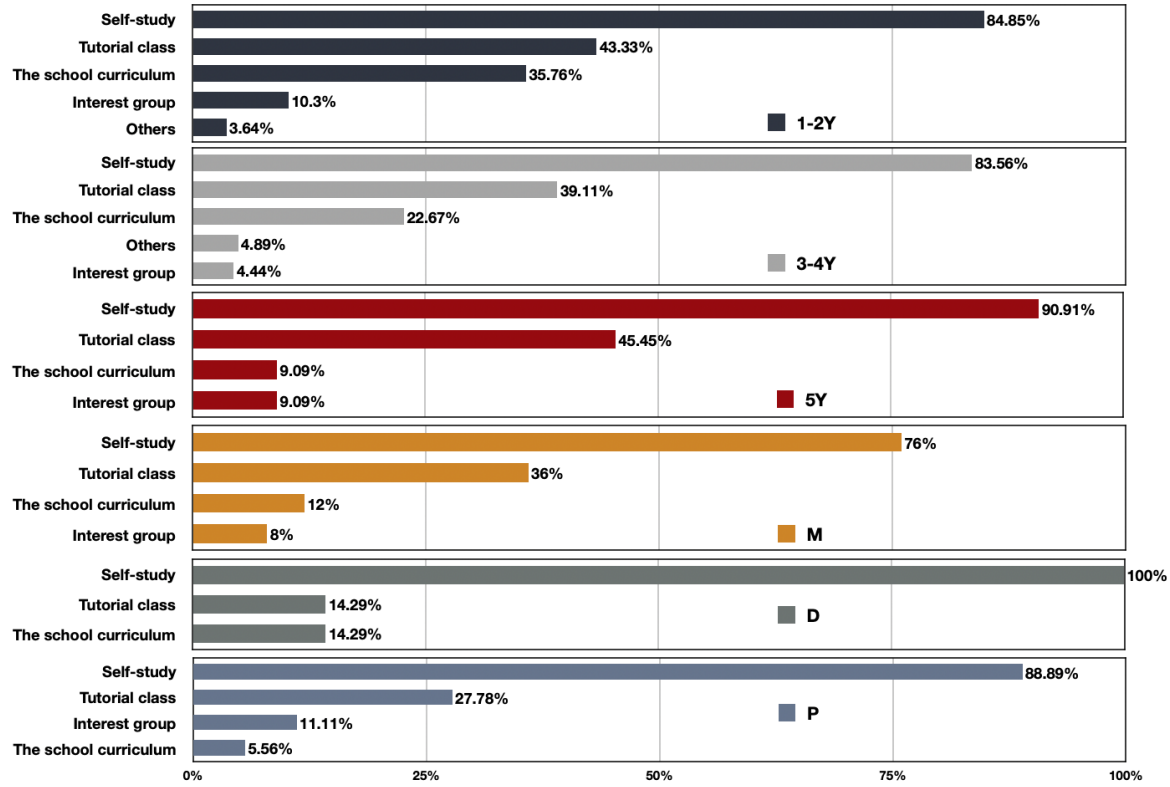


Figure 6-11 Learning methods for different learners (Multiple choice)

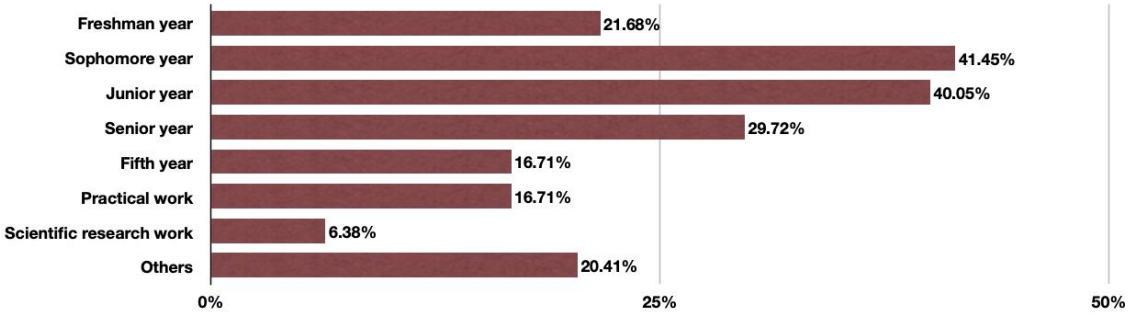


Figure 6-12 The stage of using the digital software (Multiple choice)

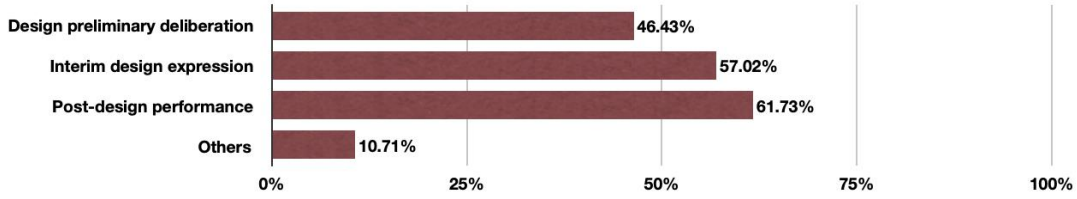


Figure 6-13 The phase of design digital software used (Multiple choice)

For questionnaires in different stages, the frequency of use of digital software is different. For the elementary stage students, 39.93 percent of them use it occasionally, 19.45 percent use it frequently, and 17.06 percent consider it a must-have tool. The probability of using digital software by development stage students is higher than that of the first two years students in every degree. The probability is 42.68 percent for occasional use, 25.61 percent for frequent use, and 21.95 percent for necessary software. For the final year students, master students, and doctoral students, 24.49 percent, 26.73 percent, and 25 percent of them did not use digital software, and 46.94 percent, 42.57 percent, and 50 percent of them only used occasionally. As can be seen from the chart, the frequency of digital software is still relatively high (Figure 6-14).

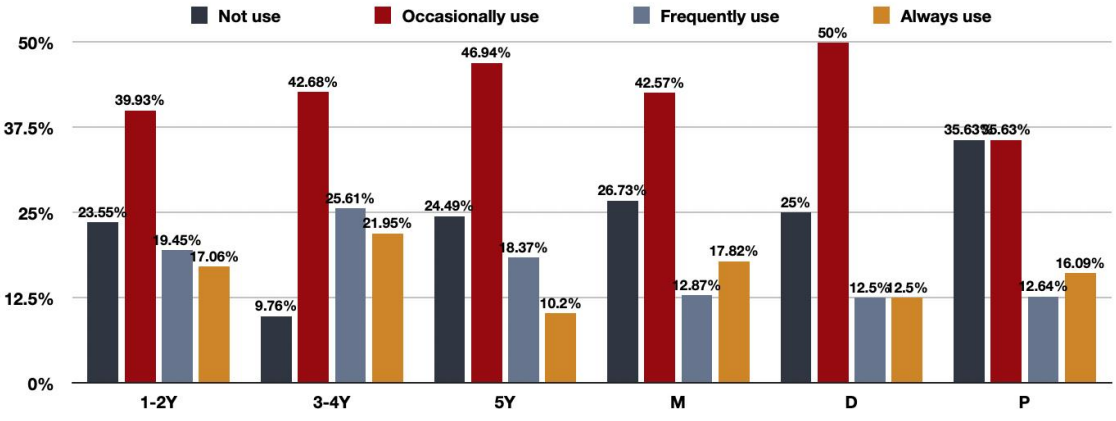


Figure 6-14 The frequency of use of digital software in different stages

In statistics, the top three of the biggest difficulties in learning software are the complex of operation commands, which is 63.65 percent; the high cost of learning time, accounting for 61.22 percent; the idea is always compromised with the model's generation logic, accounting for 45.15 percent. The remaining difficulties include: the digital modeling process

is more abstract and difficult to understand, accounting for 32.02 percent; the software has too many functions which is confusing, accounting for 27.68 percent; the functions cannot meet the needs, accounting for 10.97 percent, and finally 3.71 percent of the survey results found that digital software was not convenient to use (Figure 6-15).

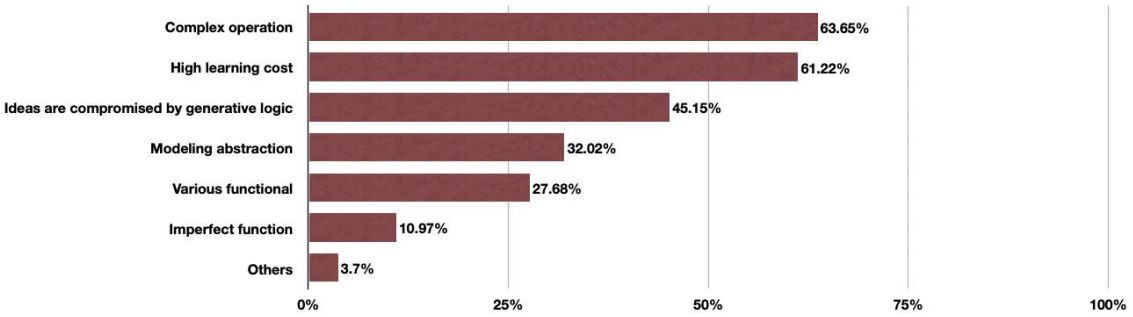


Figure 6-15 The difficulties in learning and using digital modeling techniques ((Multiple choice)

Of all 784 questionnaires, 552 questionnaires indicate that if they can, they want to contact and study digital software from the elementary stage, they want to use digital technique early, accounting for 70.66 percent; the results of 187 questionnaires are, if possible, from the development stage, accounting for 23.85 percent. Respondents of all ages wanted to learn digital software and digital technique in college. The period of anticipation of learning is concentrated in the basic phase (Figure 6-16).

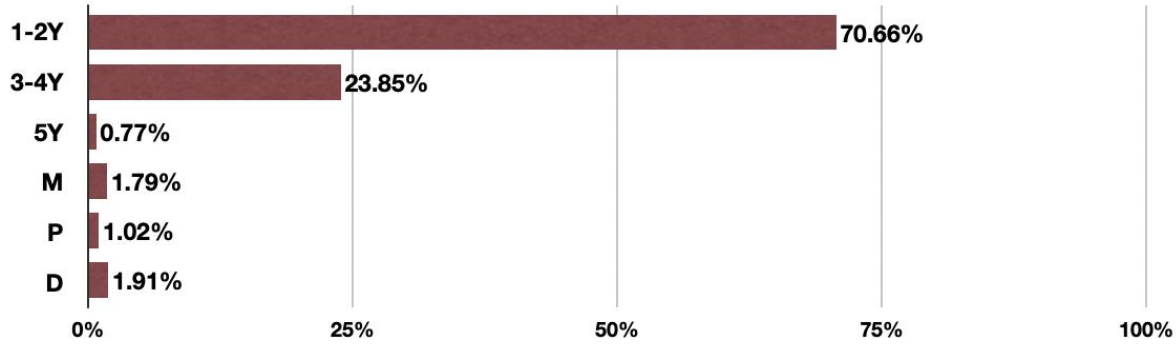


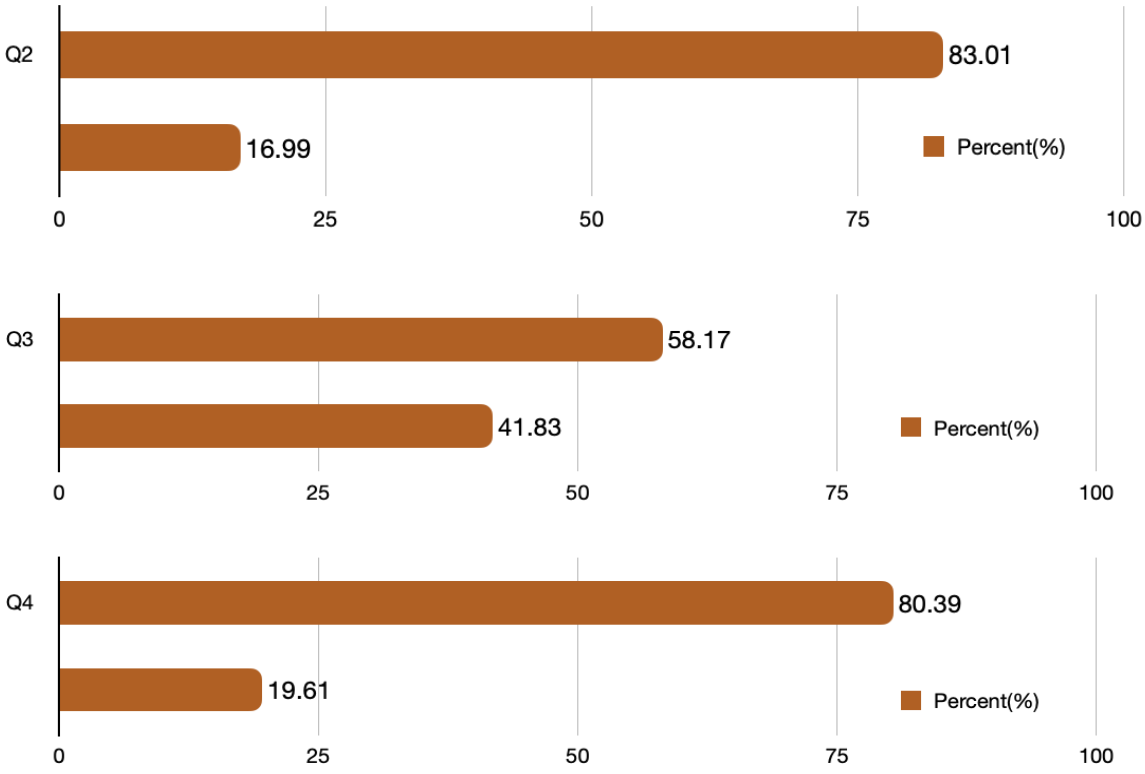
Figure 6-16 The period when you want to start learning

6.3 Results after participation

Among the 784 interviewees, 153 participated in the later course that combined digital design and traditional patterns. Participants answered the second part of the questionnaire.

- Basic background of participants

Among the 153 participants in the questionnaire survey, 127 did not have any background in digital design, accounting for 83%; only 26 had experience in digital design. Among these participants, 89 people did not understand traditional culture or traditional patterns, accounting for 58.17%; 123 people had never touched or read text or pictures that interacted or interacted with digital technology and traditional patterns. These people accounted for 80.39% (Figure 6-17) (Table 6-1).



Q:B-1: Have you had any experience in digital design before participating in the course?
Q:B-2 Did you know about traditional culture or traditional patterns before participating? Have you paid attention to traditional things?
Q:B-3: Have you ever paid attention to materials that combine digital content with traditional culture? Have you ever considered that you can borrow modern technology to reinterpret traditional things?

Figure 6-17 Basic background of participants

Table 6-1 The data analysis of basic background of participants

N	Option	Frequency	Percent	Cumulative percentage (%)
Q:B-1	1=NO	127	83.007	83.007
	2=YES	26	16.993	100.000
Total		153	100.000	100.000

N	Option	Frequency	Percent	Cumulative percentage (%)
Q:B-2	1=NO	89	58.170	58.170
	2=YES	64	41.830	100.000
Total		153	100.000	100.000

N	Option	Frequency	Percent	Cumulative percentage (%)
Q:B-3	1=NO	123	80.392	80.392
	2=YES	30	19.608	100.000
Total		153	100.000	100.000

Among the 153 students participating in the course, 51 students are very interested in traditional patterns and traditional culture, accounting for 33.3%; 83 students are more interested, accounting for 54.3% of the students participating in the survey; There are 5 students who are not particularly interested, and 14 people are not interested at all, accounting for 3.2% and 9.2% respectively (Figure 6-18).

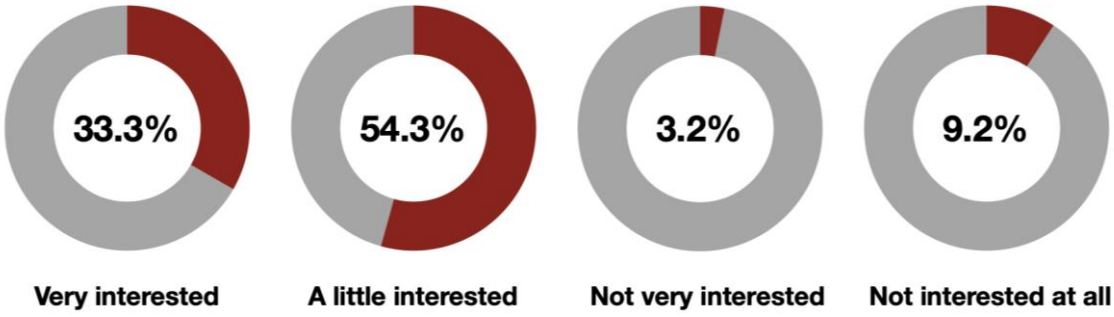


Figure 6-18 The proportion of people who are interested in traditional culture

- Feedback of use of digital software

Compared with traditional hand-drawing and traditional modeling software, 29 percent of the questionnaire surveys believe that digital software can stimulate designers' ideas and creativity and 45 percent of them think it sometimes inspires. 12 percent of the respondents think that there is not much difference between traditional and digital. But there is still 14 percent of respondents believe that digital methods are not as good as traditional methods (Figure 6-19).

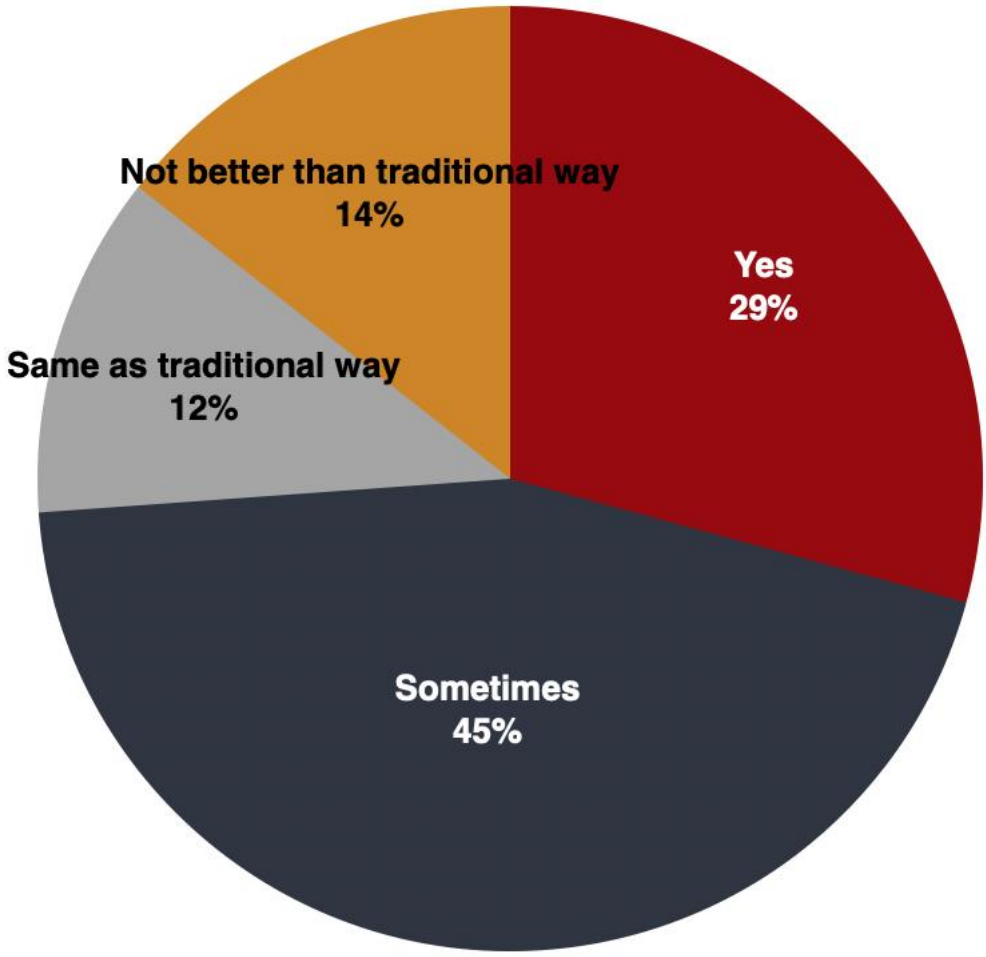


Figure 6-19 Whether digital software inspires ideas

In all questionnaires, 75.43 percent of the students in the elementary stage thought that digital applications could stimulate creativity (including 33.11 percent "Yes", 42.43 percent "sometimes"). And the data for development stage students are 26.83 percent think "yes", 49.19 percent of students think sometimes it works. The proportion of practitioners in these two parts is 37.93 percent and 33.33 percent. Because the main groups of design practice are college students and practitioners, from the data in this part, we can see that most people

think that digital tools can promote design, they have a positive impact on architecture design (Figure 6-20).

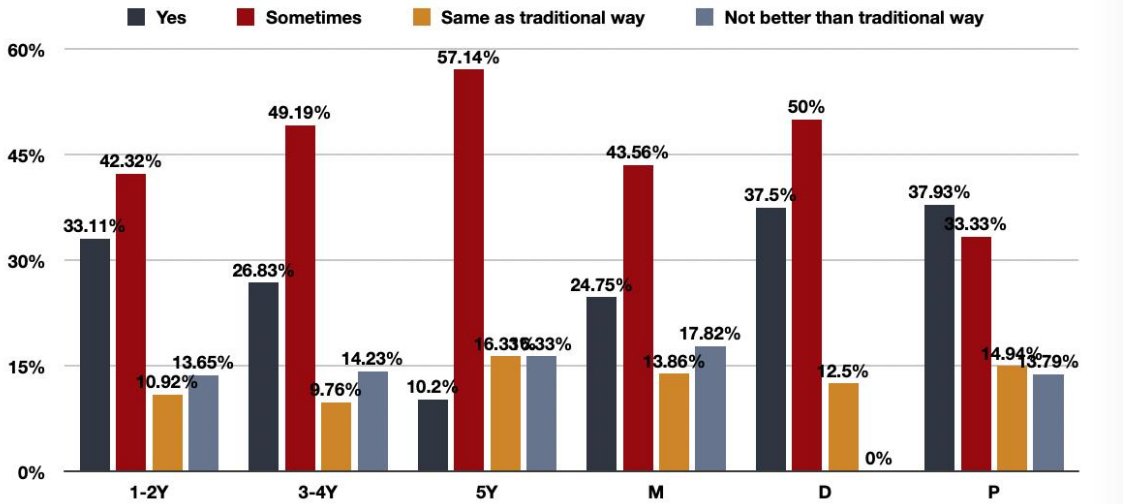


Figure 6-20 Comparison with traditional software for users at different stages

Users have different feedback and feelings when they operate the digital software. For example, 61.61 percent and 65.18 percent of them think they can help the project express and perform better. 56.51 percent of the questionnaire surveys think that digital tools are more timesaving and labor-saving, and 37.12 percent of them think that tools help to refine the design (Figure 6-21). Among those who believe that digital software is superior to traditional modeling software are not skilled users: 62.75 percent of the questionnaires who think digital techniques are more time-saving and labor-saving are zero-experience tool users; 60.82 percent who think software would promote the process of design are zero-experience tool users; 58.8 percent and 57.73 percent of the questionnaire surveys who think software owns a better expression and performance are people who can't use software. Similarly, in the results of the questionnaire survey, the software is considered to be time-consuming, labor-intensive, and not conducive to performance. The proportion of zero experience users in each item is more than half or even higher. Respondents who are skilled or proficient in software have a relatively neutral attitude toward software (Figure 6-22).

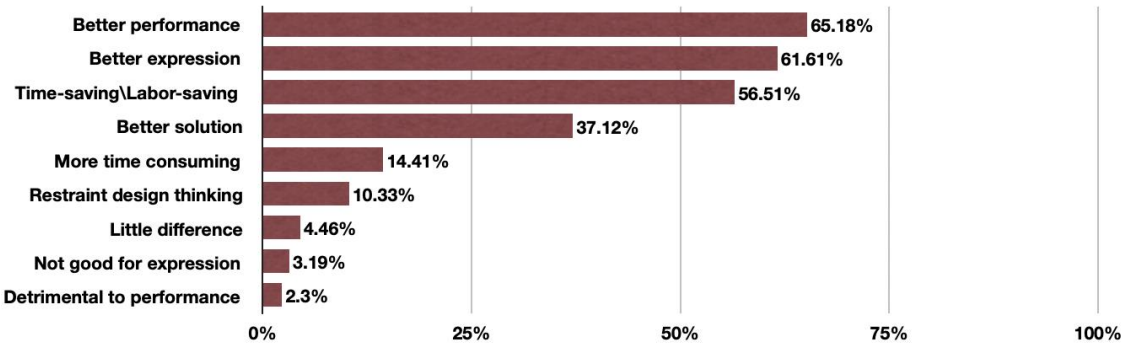


Figure 6-21 Digital techniques feature (Multiple choice)

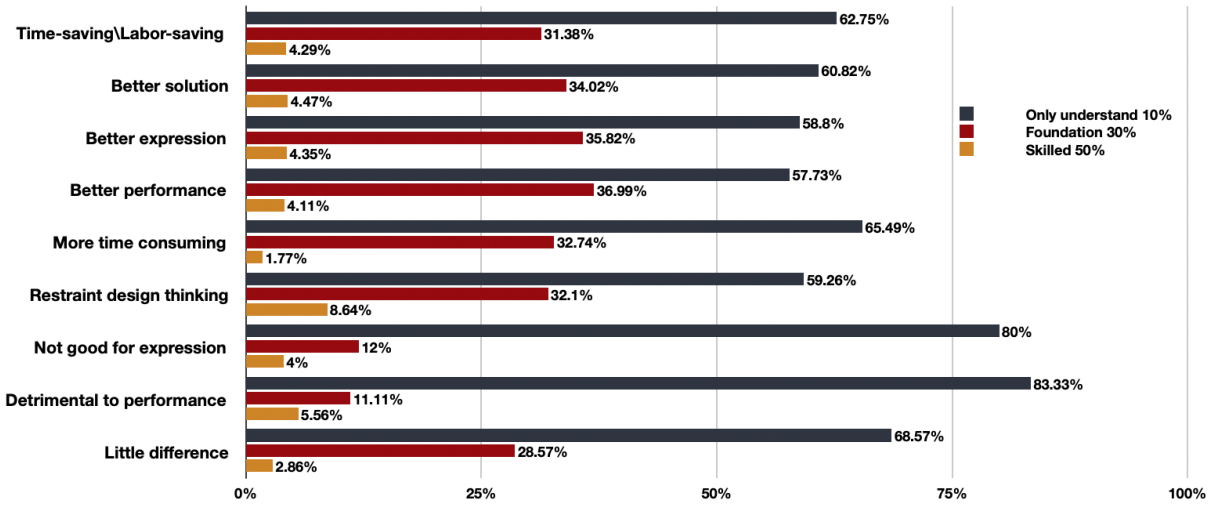


Figure 6-22 Views on digital tools by users with different mastery degree

Among all survey respondents with high learning costs, 35.21 percent of them are elementary stage students and 31.04 percent are development stage students. Respondents who choose "complex operation" is the biggest difficulty, 38.08 percent are first two-year students and 31.66 percent are in third grade and fourth-grade students. Due to the different logic of digital modeling, many students said that design thinking always compromised with model generation logic, which accounted for 34.18 percent, and 35.88 percent. These data and charts are a manifestation of the lack of systematic curriculum programs of digital techniques (Figure 6-23).

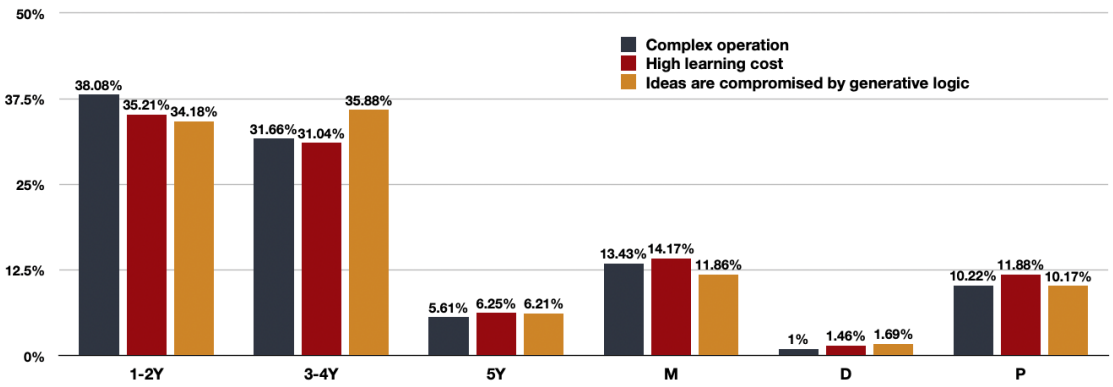


Figure 6-23 The difficulties in learning for different users

- Popularizing rate of digital tools

20.66 percent of the questionnaire survey results indicated that the surrounding learning partners and work colleagues use digital software very much, accounting for about 90 percent; 30.61 percent of people said that many architects and designers around them use digital tools, accounting for 70 percent. Only 11.73 percent said few people around them use digital software, and 2.04 percent of those surveyed said that no one around them used it (Figure 6-24). It can be seen from the chart that the majority of digital software users are college students, accounting for 75.93 percent. (46.3 percent for elementary stage students and 29.63 percent for development stage students) (Figure 6-25).

In all the surveys, 40.82 percent of the respondents believe that digital software is a skill that every designer should be proficient at, and 49.49 percent of them believe that even if they are not proficient, it is best that everyone knows and has a simple understanding about this technique. Only nearly 9% think digital software is optional. Furthermore, most respondents study and work, still like to use digital software, hoping to learn and improve this skill. They believe that the study of digital software affects career choices and academic development. The digital technology has a positive impact on the future direction of development, and more than 70 percent of the students believe that digital technology has affected their professional learning and design direction (Figure 6-26).

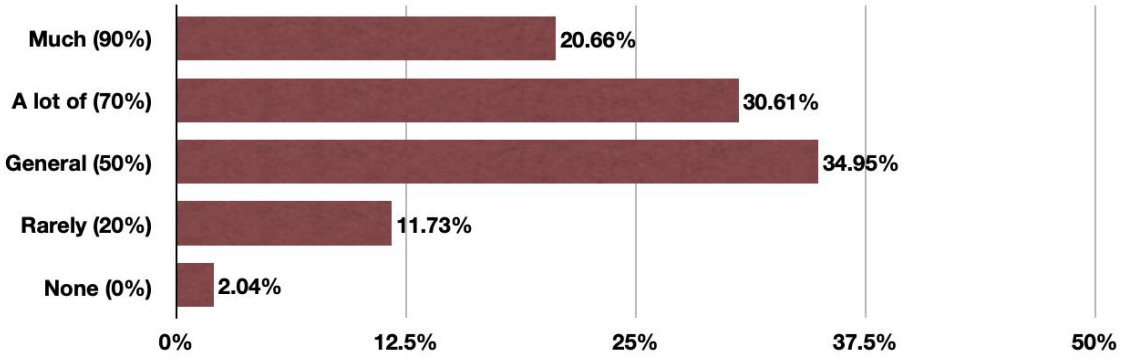


Figure 6-24 The usage status of digital tools around respondents

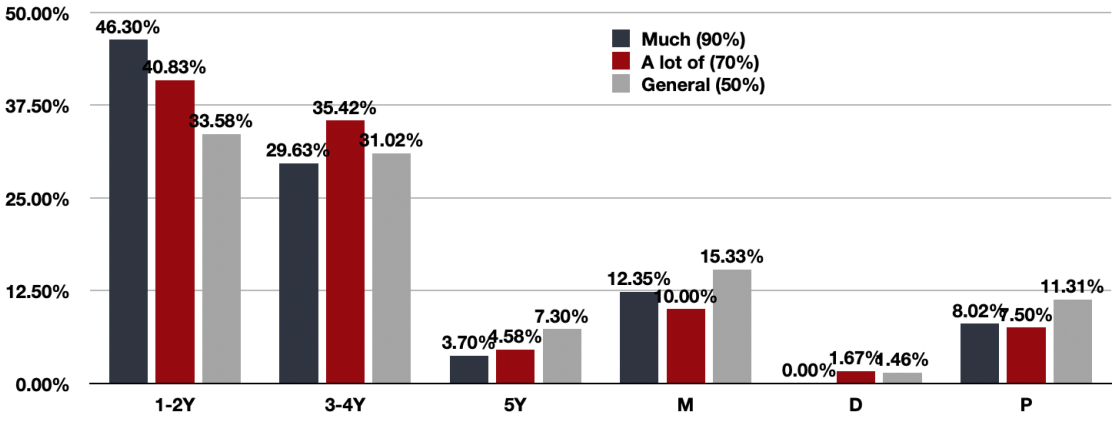


Figure 6-25 The usage status of digital tools around different stage respondents

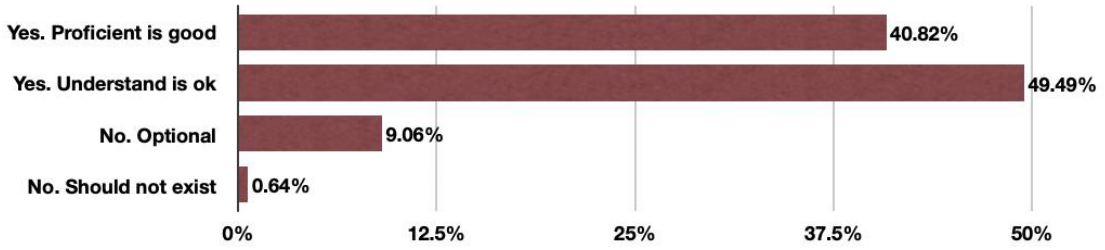
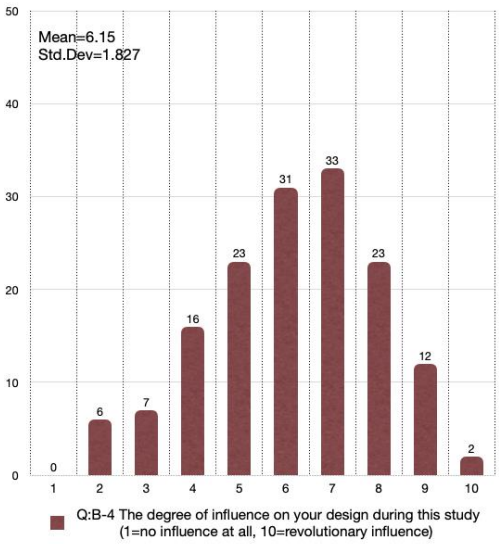
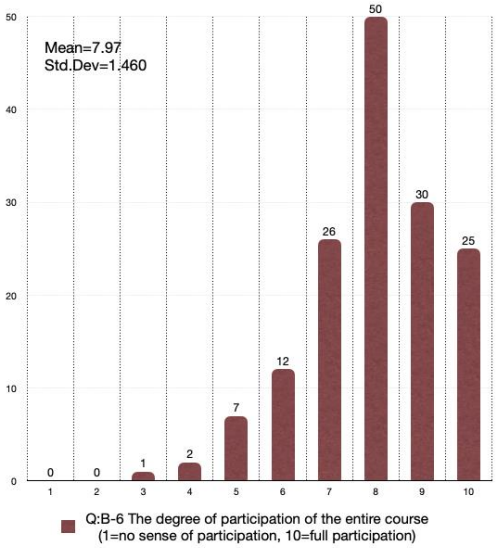


Figure 6-26 Is Digital software an essential design tool?

- Course participation feedback

As shown in Figure, all the results are normally distributed with a relevant higher average value in each question. From the values of mean, median, and mode, the frequency distribution of the workflow feedback in digital experimental showed a negative skewed unimodal distribution. It can be seen from the figure (Figure 6-27) that: (1) The participation of most students of design courses is generally high (mean=7.97, Std.D=1.46), and the participation of 150 students (98.03% of total) exceeds 50%. (2) The course is relatively difficult for students to learn (mean=6.50, Std.D=1.682) due to the lack of modeling ability using digital software for architectural design. (3) Most students believe that is very important for the entire study (mean=6.15, Std.D=1.827). It mainly for the reason that the digital modeling technology as a useful tool for generating diverse and complex forms that could bring advantages in solving more aesthetic and functional issues.





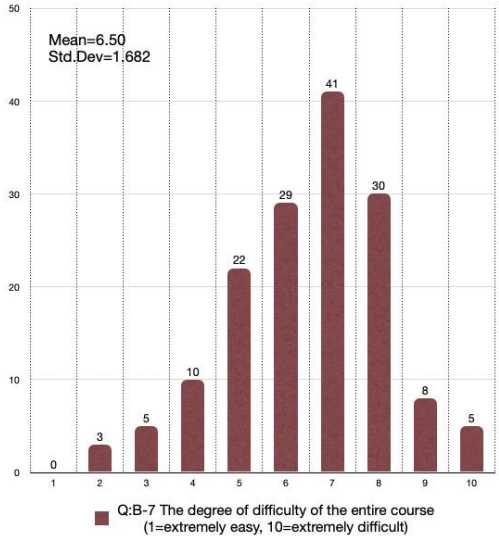


Figure 6-27 Course participation feedback

- The questionnaire results of the traditional pattern part

From the questionnaire results of the traditional pattern part (Figure 6-28 and Table6-2), it could find that there are normally distributed with a relevant higher average value in each question. The performance scores given by the greatest number of students are all 9 points and 10 points. As the Figure and Table show: (1) Because many students have not been exposed to traditional patterns before participating in the course, the novel feelings when they first encounter them will deepen their interest in traditional culture and traditional things. Therefore, the data is at a relatively high level. (mean=7.31, Std.D=1.536) It is not in the conventional architectural design curriculum. (2) Through actual operations, participants understand that traditional patterns can be represented with digital technology, or better presented. (mean=8.37, Std.D=1.56), which is also one of the reasons that affect the enthusiasm of students to participate in the course. (3) most students still believe that this stage is of significant importance (mean=8.56, Std.D=1.585), with 92.6% of students scoring more than 7. At this stage, they previewed possible redesign models of traditional patterns visually and found that this process helped to promote the digital inheritance of traditional patterns. The results show that: (1) The course content could promote students' attention to "tradition pattern" and digital design with the mean values of 7.31 for Q: B-5, 8.56 for Q: B-9, 8.37 for Q:B-8, 8.46 for Q:B-10. In this process, it helps to deepen the understanding of "the combination of traditional patterns and digital technology", which is the same as the thesis objective.

Table 6-2 Item Statistics

	Mean	Std. Deviation	N
Q:B-4	6.15	1.827	153
Q:B-5	7.31	1.536	153
Q:B-6	7.97	1.460	153
Q:B-7	6.50	1.682	153
Q:B-8	8.37	1.560	153
Q:B-9	8.56	1.585	153
Q:B-10	8.46	1.522	153

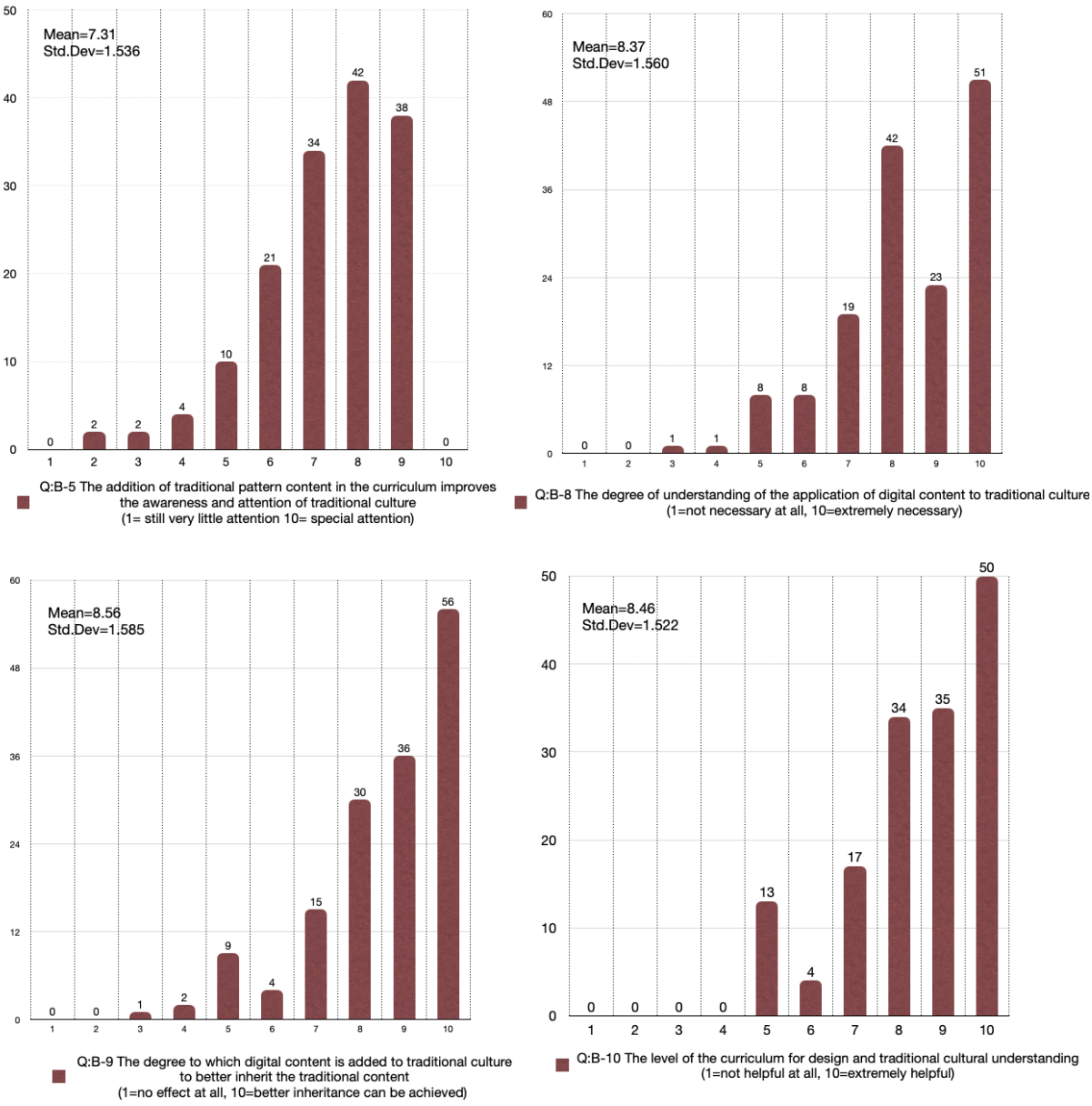


Figure 6-28 The questionnaire results of the traditional pattern part

The emergence of new digital technology has created new forms and relationships between designers, processes, and information, thus establishing new ways of design thinking with the computer application. The integration of technologies provides novel venues for design exploration. With respect to certain of the root concepts of traditional design theories and methods, it is important to share the latest concepts and techniques in design studios and integrating computer applications in architectural pedagogy. Better results can be obtained at the right time. Starting to learn digital technology in the sophomore or junior year, architecture students can own hand-drawing skill and traditional tools. And then use digital tools in the last few years of the whole architecture study. With

complete design ideas and logic, it is more effective to move between traditional tools and digital tools. As a result, the advantages are more obvious than those of students who were exposed to digital tools late in architecture. They have a more comprehensive and extensive toolset to deal with the complexities of architectural challenges.

6.4 The conclusion of quantitative analysis

Comparing the analysis of process feedback and content before and after the experiments， it can be seen that it can be seen that (1) Although the students think that digital technology is difficult to learn, they think this learning process is necessary. (2) From the perspective of participation, the addition of cultural content can make students pay more attention to tradition, and the sense of participation will gradually increase. It's a win-win in terms of digital design and heritage.

The comparative analysis of the results of the questionnaire before and after the course shows that the students have obvious views on the impact of the traditional pattern used in the digital design, the position of art inherent, and the necessity as the content of the architectural design course. Among them, the proportion of students who believed that the curriculum has a great positive influence on paying attention to traditional patterns.41.83% of the students paid attention to traditional culture and traditional patterns before the course. The mean value of these students' continued attention to traditional patterns after the course was 7.609; 58.17% of the students did not pay attention to traditional culture and traditional patterns before the course. After paying attention, the Mean value after class is 7.090 (Table 6-3).

Table 6-3 Pattern recognition data

Q: B-2	Q: B-5
1	7.609
2	7.090
Questions： *Q: B-2: Have you ever been interested in traditional culture? 1=Yes，2=No* *Q: B-5 The addition of traditional pattern content in the curriculum improves the awareness and attention of traditional culture. 1= Still very little attention 10= Special attention*	

The internal consistency assessment by Cronbach's method，Cronbach's alpha value was 0.815 (Table 6-4). This means that the students' cognition is more consistent after learning in the experiential course. In the relevant dimensions of the inheritance of traditional culture and traditional patterns, most students believe that the combination of these has a great positive influence or plays a leading role.

Table 6-4 Reliability Statistics

Item-Total Statistics					
	Mean	Std. Deviation	N	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Q:B-2	7.12	1.892	153	.667	.769
Q:B-5	7.31	1.536	153	.768	.765
Q:B-9	8.56	1.585	153	.475	.854

Summary Item Statistics							
Summary Item Statistics	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	7.455	6.503	8.556	2.052	1.316	1.069	3

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.815	0.819	3

Questions：

Q:B-2 Have you ever been interested in traditional culture? (1= not interested at all, 10= Very interested)
Q:B-5 The addition of traditional pattern content in the curriculum improves the awareness and attention of traditional culture. (1= Still very little attention 10= Special attention)
Q:B-9 The degree to which digital content is added to traditional culture to better inherit the traditional content (1=No effect at all, 10=Better inheritance can be achieved)

Similarly, the mean value of participation in courses where students have digital design experience is 7.962, the mean value of their difficulty perception is 6.000, the understanding of traditional patterns used in design is 8.385, and the mean value of the influence on later design is 6.731； The mean value of the sense of participation of students without digital design experience is 7.976, the mean value of the sense of difficulty of the course is 6.598, the mean value of the traditional pattern for design is 8.380, and the mean value of the influence on the later design is 6.031. On the whole, the difficulty of the course is moderate, and the participation of students is high. It is also helpful for students to understand the combination of design and culture, and the combination of tradition and modernity (Table 6-5). The Cronbach's alpha value of these questionnaires is as high as 0.720, indicating that the questionnaire is reliable, and the opinions are consistent (Table 6-6).

Table 6-5 Digital design data

Q: B-1:	Q: B-4:	Q: B-6	Q: B-7	Q: B-10
1	6.731	7.962	6.000	8.385
2	6.031	7.976	6.598	8.380

Questions：
Q: B-1: Have you had any experience in digital design before participating in the course? 1=Yes，2=No
Q: B-4: The degree of influence on your design during this study (1=No influence at all, 10=Revolutionary influence)
Q: B-6 The degree of participation of the entire course (1=No sense of participation, 10=Full participation)
Q: B-7 The difficulty degree of the entire course (1=Extremely easy, 10=Extremely difficult)
Q: B-10 The level of the curriculum for design and traditional cultural understanding (1=Not helpful at all, 10=Extremely helpful)

Table 6-6 Reliability Statistics

Item-Total Statistics

	Mean	Std. Deviation	N	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Q:B-4	6.15	1.827	153	0.429	0.698
Q:B-6	7.97	1.460	153	0.619	0.622
Q:B-7	6.50	1.682	153	0.266	0.756
Q:B-8	8.37	1.560	153	0.627	0.614
Q:B-10	8.46	1.522	153	0.513	0.660

Summary Item Statistics

Summary Item Statistics	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	7.492	6.150	8.464	2.314	1.376	1.186	5

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.720	0.731	5

Questions：
Q:B-4 The degree of influence on your design during this study (1=No influence at all, 10=Revolutionary influence)
Q:B-6 The degree of participation of the entire course (1=No sense of participation, 10=Full participation)
Q:B-7 The difficulty degree of the entire course (1=Extremely easy, 10=Extremely difficult)
Q:B-8 The degree of understanding of the application of digital content to traditional culture (1=Not necessary at all, 10=Extremely necessary)
Q:B-10 The level of the curriculum for design and traditional cultural understanding (1=Not helpful at all, 10=Extremely helpful)

Therefore, it can be considered that the conventional architectural design concept is necessary, but it will allow students to form inherent thinking, which has a negative effect on the acceptance of new technologies and concepts. Curriculum theory and practical education through reasonable process arrangements are effective for developing students' thinking and perceiving to adapt to the advanced architectural design concepts of the future era. All analysis of the questionnaire results quantifies the beneficial effects of this course even are highly recognized and supported by students.

In order to further verify the effects of the course and the beneficial effects on the students through the course learning practice. The questionnaire specifically set up some multiple-choice and open-ended questions, so as to collect more gratifying feedback and helpful survey responses.

In this chapter, through the questionnaire survey before and after the course participation, and the feedback analysis of the participants, we can find：

(1) In professional work and professional learning, the requirements for digital technology and digital software are constantly improving, which is also an inevitable demand for the development of the industry; however, many colleges and universities in China do not systematically carry out teaching in this area; students are self-study There are also great difficulties in the process, and there is no suitable way or systematic learning.

(2) The importance and attention of students to traditional culture and traditional patterns will be significantly improved through the results of the questionnaire survey, which reflects the students' sense of identity with traditional things. This kind of teaching philosophy has a deep understanding of cultural thoughts through deep participation.

Reference

1. Kara, L., A critical look at the digital technologies in architectural education: when, where, and how? Procedia-Social and Behavioral Sciences, 2015. 176: p. 526-530.

2. Abdelhameed, W., Architectural form creation in the design studio: physical modeling as an effective design tool. ArchNet-IJAR: International Journal of Architectural Research, 2011. 5(3): p. 81.

3. Oxman, R., Theory and design in the first digital age. Design studies, 2006. 27(3): p. 229-265.

4. Oxman, R., Digital design thinking: in the new design is the new pedagogy. 2006.

5. Holzer, D., Design exploration supported by digital tool ecologies. Automation in Construction, 2016. 72: p. 3-8.

6. Soliman, S., D. Taha, and Z. El Sayad, Architectural education in the digital age: Computer applications: Between academia and practice. Alexandria Engineering Journal, 2019. 58(2): p. 809-818.

7. Soliman, A.M., Appropriate teaching and learning strategies for the architectural design process in pedagogic design studios. Frontiers of architectural research, 2017. 6(2): p. 204-217.

8. Zboinska, M.A., Influence of a hybrid digital toolset on the creative behaviors of designers in early-stage design. Journal of Computational Design and Engineering, 2019. 6(4): p. 675-692.

9. Weisberg, R.W., Creativity: Understanding innovation in problem solving, science, invention, and the arts. 2006: John Wiley & Sons.

10. Cross, N., Descriptive models of creative design: application to an example. Design studies, 1997. 18(4): p. 427-440.

11. Paker Kahvecioğlu, N., Architectural design studio organization and creativity. A| Z ITU Journal of the Faculty of Architecture, 2007. 4(2): p. 6-26.

12. Visser, W., The cognitive artifacts of designing. 2006: CRC Press.

13. Henri H, A., New design methods for computer aided architectural design methodology teaching. International Journal of Architectural Computing, 2003. 1(1): p. 72-91.

14. Guney, D., The importance of computer-aided courses in architectural education. Procedia-Social and Behavioral Sciences, 2015. 176: p. 757-765.

Chapter 7 Discussion and Conclusion

7.1 Discussion:

The digital redesign of patterns requires some basic knowledge of patterns, including types and forms. A set of steps is constructed throughout the research process that can establish a tangible, non-computational connection to Design Thinking for understanding and development to ensure the entire process. Mathematics can be seen as the search for regularities, and the output of any function is a mathematical pattern. Similarly, in the sciences, theories explain and predict regularities in the world. In art and architecture, decorations or visual motifs may be combined and repeated to form patterns designed to have a chosen effect on the viewer.

- Inheritance in the traditional sense is written in words. The digital practice encourages students to do reading first. Learn to respect more existence. With digital media as the carrier of traditional culture, we strive to break through the boundaries and develop new forms, new styles, and new aesthetics. Liminal form, constantly evolving the relationship between systems to create forms that are held in maximal tension in relation to one another, suspended in a permanent state of incomplete transition. This incomplete transition allows designers to recognize originality. It is like an "intermediate state" open system that allows mutations to grow indefinitely. It is an expression of aesthetic sustainability and multiple possibilities. The creative transformation and innovative development of Chinese patterns are the manifestations of the modern value of traditional culture. It is a digital inheritance, seen by more people, remembered by more people. Under the leadership of scientific and technological progress, the design will once again activate its metabolism and body renewal, create a visual style that is most in line with the development of the times, and will also find a new path for the inheritance of traditional culture.
- Digital Design has already had a remarkable effect on architectural design. It could easily bring interdisciplinary techniques of design and multifaceted knowledge together for generating and analyzing in a digital environment. As the first component of the design practice, digital design asks students to focus on the digital modeling of design concepts through the traditional pattern. In this stage, the graphic logic-based digital architectural model is established and becomes a platform for the upcoming simulation, application, experimentation of the pattern redesign. Digital design technology could help students explore more design possibilities. It breaks the constraints of the two-dimensional plane,

allowing the designer to consider the design with a three-dimensional posture, allowing the audience to experience the design from a dynamic and participatory perspective. Take "simple pattern element" as an example. We guided students to experiment with two-dimensional graphic logic in order to achieve a creative solution for a new component more flexible. It was clear that this experiment brought novel sustainability and critical concept thinking into their design.

- Complex component practice requires students to understand the different steps of design (such as the simplified design process, the exuberance design process) and merge them into one design practice, which provides a complete path for students or architects to analyze each step of design in order to clarify the application of traditional patterns. Finally, the diversified application form is closely related to the precipitation of culture and the development of technology. Based on technical presentation and media conversion, it will become a constantly changing visual form with unknown results. The boundaries of design forms will disappear, and the boundaries of design-related knowledge will also disappear. The boundaries between "professional" and "non-professional" in design will be washed away, and multiple "non-design" expertise will flood into the design. In the process, the design becomes completer and more comprehensive. However, the overall ability will be greatly strengthened, and the open design boundary breaks through the limitations of human cognitive ability.

7.2 Conclusion-What's new?

Chapter 1 intends to construct the initial background and form the first delineation of thematic and instrumental approaches. The research background is elaborated from three aspects: pattern, digital development, and form beauty. The pattern has a long development period and covers a wide range. The presentation method is rather limited. Due to the limitations of technology, traditional Chinese patterns are only presented by the two-dimensional. Under "digital technology", the design has more possibilities and openness. The boundaries of formal beauty are no longer limited. The early study of patterns remains on a single theme the traditional methods of inheritance are simple. The possibilities of combining technology and art are not fully exploited. So, the objective of the research is to explore the possibility of traditional patterns based on digital design and support the inheritance of traditional culture.

Chapter 2 intends to construct two parts of the cultural background and technology of the research project. The whole process of pattern development is sorted out through literature study, with figures and texts. No matter what kind of pattern, it is a development process from simple to complex. The development of patterns and the replacement of dynasties, people's lives, and foreign cultures are related. Patterns represent specific connotations. With the emergence and development of digital technology, the product of architecture is not only buildings and space. It is also the development of new knowledge, organization, and technique. The technology available affects the language of architecture, bringing a huge cultural shift from multidisciplinary to interdisciplinary design processes.

Chapter 3 intends to clarify the approach to research taken within the thesis by elaborating on an architectural research methodology that is based on the objective of the thesis. Through three fields study of graphic analysis studies, digital design experiments, quantitative analysis on teaching feedbacks, and online data analysis, a mixed-method research strategy is applied in this thesis. Pattern research and digital design research are carried out layer by layer based on three methods, to the theme of the study, which is evolving around how we think and understand traditional things and architecture practice, it ought to be relevant to several aspects of the profession.

Chapter 4 focuses on the analysis of pattern graphics and its role in traditional Chinese pattern classification and skeleton structure, reveals the logic of the composition of traditional Chinese patterns, and triggers the initial steps of the entire design.This chapter introduces the characteristics and analysis methods of pattern graphics and then extends it

to the composition methods of traditional Chinese patterns, including individual patterns, continuous patterns, etc. The compositional characteristics of Chinese traditional patterns are influenced by Chinese philosophical thoughts and contain unique meanings of elements. Traditional patterns of skeletons also have Chinese characteristics, including Taiji skeletons and Jiugongge skeletons. All of these provide the theoretical basis and graphic logic for the later operation experiment.

Chapter 5 focus on the process of the combination of Architecture Design and traditional culture, revealing the possible design form of digital modeling-based traditional pattern conception. Take the traditional pattern as a prototype. Abstract and transform the essential elements. Combine the regenerated model with the existing old building. The experiments are based on traditional pattern graphics. First step: Confirm the graphic logic and modulus relationship behind individual patterns and continuous patterns from their essence. Describe the relationship or structure from the accurate perspective of graphics. Complete the interpretation from graphics to diagrams in the design. Under digital technology, the designers try to transform complex and multi-category information into measurable numbers and data. Complex patterns are embodied, realistic, and refined into single elements which can be used for design. It is a process from complex to simple. Then, through software processing, digital models are more sculptural. Designers use digital technology to break the standard interface orthogonal relationship of building. They try to apply shapes with free-form surfaces and irregular morphological interfaces to structures. Extremely complicated geometric forms under the control of parameters constitute a variety of visual effects with limited components. The use of these complex components in architecture makes the building more contemporary and impactful. That is, it demonstrates the value of multiple aesthetics and sociality. It is a process from simple to complex.

1) In terms of design, advanced digital technology and sculpting software has changed the designer's original scope of practice and thinking method, optimized the designer's understanding and insight, and become a medium that reflects human complexity thinking.

2) Students can have more precise insights and a deeper understanding of new concepts. The whole process integrates the use of an aesthetic sensibility concomitant with highly developed design ability. It is a systematic thinking logic to prevent the effects of habitual processes. Students should realize that design equals energy, enthusiasm, excitement, and inspiration. To cultivate personal aesthetic ability from the elementary stage is the sustainability of education and learning.

3) This novel pedagogical framework explores the complete cycle of architectural design. It represents a methodical approach to "cells to organ, organs to systems, systems to new speciation", providing students with the necessary technical skills.

Chapter 6 focuses on the analysis of the process. First, it analyzes and describes the recruitment information of the units designed by 316 and the 784-questionnaire survey. The empirical analysis proved the necessity of digital design in the learning process. 153 of the 784 participants participated in the course. Based on feedback, it proved that the combination of digital design and traditional patterns can create structural thinking for design inspiration. Major efforts have been made to promote the inheritance and attention of traditional patterns. In this chapter, through the questionnaire survey before and after the course participation, and the feedback analysis of the participants: In professional work and professional learning, the requirements for digital technology and digital software are constantly improving, which is also an inevitable demand for the development of the industry; however, many colleges and universities in China do not systematically carry out teaching in this area; students are self-study There are also great difficulties in the process, and there is no suitable way or systematic learning. The importance and attention of students to traditional culture and traditional patterns will be significantly improved through the results of the questionnaire survey, which reflects the students' sense of identity with traditional things. This kind of teaching philosophy has a deep understanding of cultural thoughts through deep participation.

What's new

Digital technology, not simply as a design tool but as a design medium, enables human designers and their social-cultural settings to produce unknown ideas during the design thinking process. As we believe the digital age will change the design world even more dramatically than it has done so far, we ask what else can the digital medium stimulate or associate in regard to creative design. According to the above studies of the combination of tradition and modernity, breaking the circle of research will play a possible role in pursuing design creativity in the future. The graphic analysis is used in both the personal and social-cultural thinking of architectural design. Because of digital breakthroughs, new possibilities of design will inevitably excite new ways to perceive domain knowledge. New ways of thinking and making domain knowledge will inevitably excite variations, extensions, and the as yet unknown. The new set of the design framework relates to the redefinition of domain knowledge for both personal and social/cultural design thinking. Several new findings from the whole study：

- Discover the inner logic of the research process of traditional aesthetics.
- Ancient Aesthetic Logic Visualization.
- Use prototype logic to develop traditional aesthetics in multiple ways and in multiple directions quickly.

Appendix

1. CHINA—Timeline of Historical Periods

Primitive society	-2070 BC	Song	420-479
Slave society	2070-476 BC	Qi	479-502
Xia Dynasty	2070-1600 BC	Liang	502-557
Shang Dynasty	1600-1050 BC	Chen	557-589
Zhou Dynasty	1046-256 BC	Northern Dynasties	386-581
Spring and Autumn Period	770–475 BC	Northern Wei	386-534
Feudal Society	475 BC -1840	Eastern Wei	534-550
Warring States Period	475–221 BC	Western Wei	535-556
Qin Dynasty	221-206 BC	Northern Qi	550-577
Western/Former Han	206 BC-25	Northern Zhou	557-581
Eastern (later) Han	25-220	Sui Dynasty	581-618
Three Kingdoms	220-280	Tang Dynasty	618-907
Wei	220-265	Five Dynasties and Ten Kingdoms Period	907-960
Shu	221-263	Northern Song	1279
Wu	222-280	Southern Song	1127

Western Jin Dynasty	265-317	Liao Dynasty	907-1125
Eastern Jin Dynasty	317-420	Jin Dynasty	1115-1234
Five Hus and Sixteen States	304-439	Yuan Dynasty	1206-1368
Northern and Southern Dynasties	420-589	Ming Dynasty	1368-1644
Southern Dynasties	420-589	Qing Dynasty	1616-1911

2. Teaching Questionnaire

In order to effectively analyze the teaching effect of this course, I hope you can take a few minutes to tell us your feelings and suggestions. We attach great importance and look forward to the valuable opinions of each participating student in this course. Let's start now!

Basic information：

1.What is your learning stage now?

A: Elementary stage students

B: Development stage students

C: Mastery stage students

D: Master students

E: Doctoral students

F: Practitioners

A：Before attending the course

Q: A-1 Do you know how to use digital modeling software, like Rhino, Grasshopper, Maya?

A: understand 10%

B: Foundation 30%

C: Skilled 50%

D: Proficient 80%

Q: A-2 When did you start to learn digital software?

A: Elementary stage students

B: Development stage students

C: Mastery stage students

D: Master students

E: Doctoral students

F: Practitioners

G: Never touched

Q: A-3 The purpose to learning digital software. (Multiple choice)

Career development needs

A: Field development trend

B: School curriculum
C: Personal interest
D: Peripheral influence

Q: A-4 The main way to learn digital software (Multiple choice)
A: Self-study
B: Interest group
C: Tutorial class (network class, physical class)
D: The school curriculum
E: Others

Q: A-5 At what stages have you used the software? (Multiple choice)
Freshman year
Sophomore year
Junior year
Senior year
Fifth year
Practical work
Scientific research work
Others

Q: A-6 At what phase of your design was digital software used? (Multiple choice)
Design preliminary deliberation
Interim design expression
Post-design performance
Others

Q: A-7 Compare with hand-drawing and traditional modeling software, digital modeling software. (Multiple choice)
A: Timesaving\Labor-saving
B: Better solution
C: Better expression
D: Better performance
E: More time consuming
F: Restraint design thinking
G: Not good for expression

H: Detrimental to performance
I: Little difference

Q: A-8 What is the usage status of digital software around you?
A: Much (90%)
B: A lot of (70%)
C: General (50%)
D: Rarely (20%)
E: None (0%)

Q: A-9 Compared with traditional modeling software, what are the difficulties in learning and using digital modeling software? (No more than three choice)
A: Complex operation
B: High learning cost
C: Ideas are compromised by generative logic
D: Modeling abstraction
E: Various functional
F: Imperfect function
G: Others

Q: A-10 If so, at what stage do you want to get started with digital software?
A: Elementary stage students
B: Development stage students
C: Mastery stage students
D: Master students
E: Doctoral students
F: Practitioners
G: Others

B：After attending the course

Q: B-1: Have you had any experience in digital design before participating in the course?
（1=Yes，2=No）

1	2

Q: B-2: Have you ever been interested in traditional culture?

（1=Yes，2=No）

1	2

(1= not interested at all，10= Very interested)

1	2	3	4	5	6	7	8	9	10

Q: B-3: Have you ever paid attention to materials that combine digital content with traditional culture?

（1=Yes，2=No）

1	2

Q: B-4: The degree of influence on your design during this study

(1=No influence at all, 10=Revolutionary influence)

1	2	3	4	5	6	7	8	9	10

Q: B-5 The addition of traditional pattern content in the curriculum improves the awareness and attention of traditional culture.

(1= Still very little attention 10= Special attention)

1	2	3	4	5	6	7	8	9	10

Q: B-6 The degree of participation of the entire course

(1=No sense of participation, 10=Full participation)

1	2	3	4	5	6	7	8	9	10

Q: B-7 The difficulty degree of the entire course

(1=Extremely easy, 10=Extremely difficult)

1	2	3	4	5	6	7	8	9	10

Q: B-8 The degree of understanding of the application of digital content to traditional culture

(1=Not necessary at all, 10=Extremely necessary)

1	2	3	4	5	6	7	8	9	10

Q: B-9 The degree to which digital content is added to traditional culture to better inherit the traditional content

(1=No effect at all, 10=Better inheritance can be achieved)

1	2	3	4	5	6	7	8	9	10

Q: B-10 The level of the curriculum for design and traditional cultural understanding

(1=Not helpful at all, 10=Extremely helpful)

1	2	3	4	5	6	7	8	9	10

Q: B-11 Does digital software inspire your design ideas as compared to hand drawing and traditional modeling?

A: Yes

B: Sometimes

C: Same as traditional way

D: Not better than traditional way

Q: B-12 Is digital software still your high-frequency software?

A: Not use

B: Occasionally use

C: Frequently use

D: Prerequisite software

Acknowledgements

With completing my thesis just around the corner, I look back on my doctorate journey with a lot of emotion. I am very grateful to my supervisor, colleagues, classmates, and family members who have provided me with so much help in my studies and life over the past three years. Without their support, guidance, and assistance, this thesis would not have been completed.

First of all, I would like to express my sincere gratitude to my supervisor, Professor Bart from Kitakyushu University, who has given me a lot of guidance and help in my thesis writing, which has made it possible to proceed smoothly. His vast academic knowledge and rigorous approach to science have influenced my research work all the time. Moreover, he also gave me a lot of encouragement and support in my daily life.

secondly, I would like to thank all the students in my project team for the many hours of hard work and sweat they put into the research. Because of their help, I was able to overcome one difficulty after another in my thesis.

Finally, I am very grateful to my family for their endless love, encouragement, and moral support in my life, which gave me enough confidence to overcome the difficulties.