

A NEW PERSPECTIVE TO LOOK AT ICE-RAY GRAMMAR

XIAOFANG YUAN,¹ JI HYUN LEE,² and YU WU³

KAIST, Daejeon, Republic of Korea

1. yuanxiaofang@kaist.ac.kr, 2. jihyunlee@kaist.ac.kr;

3. wuyu@kaist.ac.kr

Abstract. Chinese lattice designs are a rich source of interesting geometric forms and shape grammar has been used to analyze and generate Chinese lattice designs. Following the origin design intention, researchers have already defined simple and intuitively compelling shape grammar rules to generate them. However, for some self-similar ice-rays, it is difficult to clarify the design intention of them, which is why researchers still cannot define shape grammar rules for them. In this paper, we utilize the culture hints to select the lowest-level constituent for shape calculation and clarify the design intention embedded in the ice-rays. We develop our new shape grammar rules based on the design intention and validate the rules by generating an existing ice-ray window.

Keywords. Ice-ray; shape grammar; cultural hint; design intention; lowest-level constituent.

1. Introduction

Chinese lattice designs are a rich source of interesting geometric forms and shape grammars have been used as a means to describe the designs of the Chinese lattice. Daniel Sheets Dye catalogued various Chinese lattice designs constructed between 1000 BC and 1900 AD into 26 general types in his classic work *A grammar of Chinese lattice*. Some Chinese lattice designs in Dye's *Grammar* are regular patterns and some are irregular designs, like "ice-rays". Stiny (Stiny 1977) demonstrated that shape grammar can generate both types of the Chinese lattice designs in Figure 1: a periodic tiling and a self-similar ice-ray. However, for the self-similar ice-ray, stiny's grammar cannot generate all of them. There are still some ice-rays cannot be generate by shape grammar

and the ice-ray in Figure c is the one.

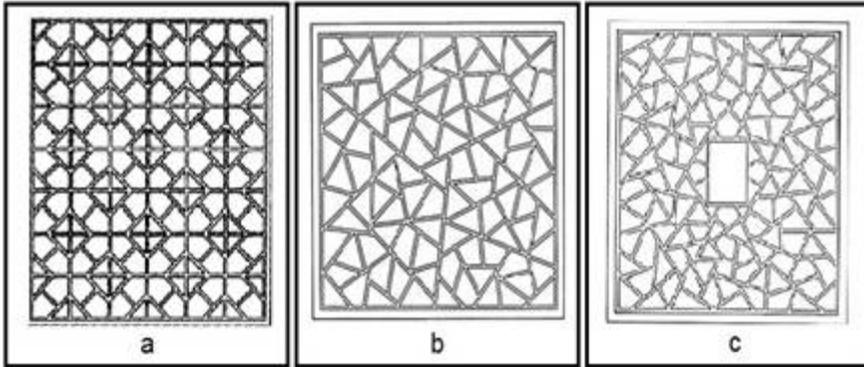


Figure 1. Three typical Chinese lattice designs a) a regular tiling; b) an irregular ice-ray, Chengtu, Szchwan, 1880; c) an irregular self-similar ice-ray

2. Background

Shape grammar has been used to define the language of designs such as ornamental art (Knight 1980; Knight 1981; Stiny 1977), architecture (Downing and Fleming 1981; Koning and Eizenberg 1981; Stiny and Mitchell 1978) and landscape design (Knight 1989; Knight 1990; Stiny and Mitchell 1980), transforming the verbal conventions of the composition into explicit visual shape rules. When the researcher defines the language of a design, he tries to find out the design intention and describe it by shape grammar rules. Koning and Eizenberg (1981) developed parametric shape grammar rules that can generate the composition and specify the function zones of Frank Lloyd Wright's prairie-style houses. In their word, the grammar they developed can be viewed as a formalization and elaboration of Wright's compositional principles for prairie-style houses in many ways. Moreover, they declared that the development of the grammar clarifies their understanding of the composition of Frank Lloyd Wright's prairie-style houses. Stiny's grammar can generate ice-ray designs in a very simple and intuitively compelling way (Figure 2). When Stiny described the ice-ray designs, he also tries to investigate the conventions used to construct Chinese ice-ray designs and develop the parametric shape grammars that can describe the making process.

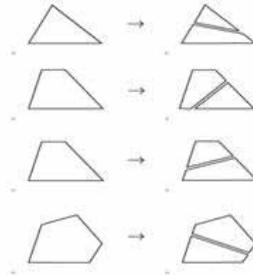


Figure 2. Stiny's shape grammar rules for ice-ray

Later, for the ease of computer implementation, Tapia (Tapia, 1992) generated new shape rules for the ice-ray designs (Figure 3). He followed the design intention Stiny used to describe ice-ray designs and he considered the way to implement the shape rules in computers. Liew put his focus on the dependency between shape grammars and computer implementation and categorized shape grammar rules for the Chinese ice-ray designs into 4 sub-categories: 1) simple parametric grid shape grammar rules; 2) parametric shape grammar rules; 3) constrained parametric shape grammar rules; and 4) unknown shape grammar rules. The ice-ray design c in Figure 1 belongs to the fourth which cannot generate by existing shape grammar rules.

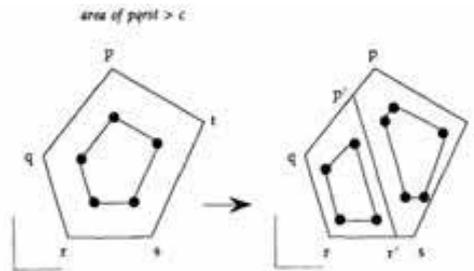


Figure 3. Tapia's shape grammar rule for ice-ray

The mentioned researches about Chinese lattice designs all follow the design intention described in Dye's book and their shape grammar rules cannot cover all the ice-ray designs. In this paper, we argue that Dye's understanding on Chinese ice-ray design is not completely correct. We try to find out the design intention embedded in the Chinese lattice design by utilizing cultural hints and define new shape rules that can generate the ice-ray designs.

The rest of the paper is organized as follows. In Section 3 we try to decompose the lattice pattern with different lowest-level constituents and argue the connection between the constituent and cultural hints and hypothesize the

design intention of Chinese lattice. In Section 4 we define and validate shape rules based on design intention. Finally, we conclude with discussions and future research direction.

3. Design intention embedded in Chinese lattice design

We choose the Chinese lattice window in Figure4 as an example to find out how to decompose it into the lowest-level constituent and the design intention embedded in it. At first, we define the shape rules and the corresponding lowest-level constituent that can generate the lattice pattern. Then, the meaning of lowest-level constituent will be examined to trace the design intention embedded in the lattice window.

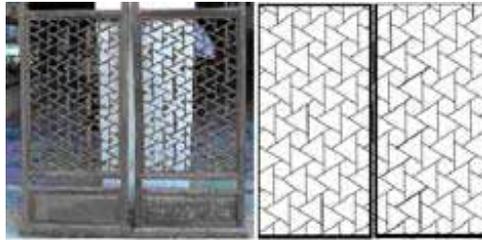


Figure 4. A Chinese lattice window

3.1. THE LOWEST-LEVEL CONSTITUENT FOR CALCULATION

The chosen window can be categorised into checkerboard design. Stiny used two schemas for the checkerboard designs. The first one is $x \quad x + t(x)$ to produce the checkerboard pattern and the second is $x \text{div}(x)$ to inscribe the given motif and divide squares (Stiny, 2006, p331). The chosen window can be generated by using stiny's schemas if we choose one of the motifs as shown in Figure 5.

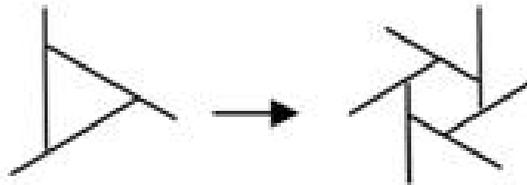


Figure 5. Two motifs for generating lattice window

It is very interesting to find that the chosen window can be generated by two different motifs. But this raises the problem. Which one can represent the

design intention embedded in the lattice window?

This problem rises every time when you calculate with shape. When we divide the shape into the lowest-level constituents, we can segment shape into lowest-level constituents in many different ways. This causes the questions like which way of segmenting shapes into constituents make the most sense in terms of what we want to calculate? Which analysis works best? Stiny suggested that we can dynamically change the constituent while we make the rules until we find the suitable one that can help calculate the shape. In the book “Shape: Talking about Seeing and Doing”, Stiny illustrated the problem about decision making when he faced several choices to segment the shape. He thought it is critical to choose the suitable way to divide shape into the lowest-level constituents, especially when someone is dealing with the design problem (Stiny, 2006). He pointed out that the way to choose the constituents to segment the shape depends on the rules he used and gave an example to show his idea (Figure 6).

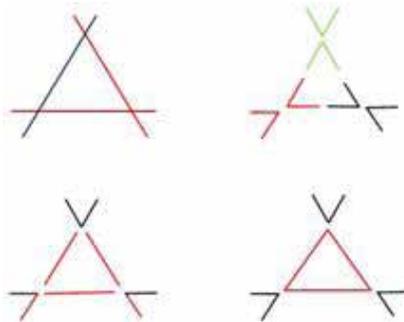


Figure 6. Four different ways to segment the triangle

3.2. THE CULTURAL INFORMATION IN THE PATTERN

When we treat the window as a checkerboard design, the motif becomes the lowest-level constituent to calculate. We do not use rules to describe the motif and we may miss the information in it because it is merely considered as a shape. Design is an intention activity and design intention will be influenced by cultural context inevitably. While many cultures create designs with geometric patterns, each has distinct motifs and symmetries. The pattern of Chinese lattice window may contain some cultural information which influenced the design intention. As Dye (1947) described ice-ray in his book *A Grammar of Chinese Lattice*.

I have described it [ice-ray] as the result of a molecular strain in shrinking or breaking, but more recent observations and photographs seem to prove

that it is a conventionalization of ice-formation which has become traditional. (Dye, 1949, page 298)

Ice-ray lattice is not merely the imitation of natural phenomenon and it has become the pattern which contains some cultural information and design intention. In this paper, we propose a new way to select the lowest-level constituent for calculation. We utilize the cultural hints that are related to Chinese lattice window to determine the lowest-level constituent. In doing so, we may find out the embedded design intention and describe it by shape grammar rules.

In Chinese traditional building of Huizhou region, we can find the special ice-ray pattern which consists of a hexagon in the centre named “XuanJi” in Chinese ornamental pattern and the “Human shape” composed by every two bars around the hexagon. The pattern is to show the emphasis of human and the harmony of human and nature.

Based on the understanding of the cultural information of the ice-ray pattern, we propose a new perspective to look at the design intention of it. The lowest-level constituent of the window should be the “Human shape” and when the Chinese artisan makes the windows, the design intention is to embed the “Human shape” in it.

It is not hard for us to find the “Human shape” in the previous motifs (Figure 7). To define the new shape rules for the lattice design, we should consider the “Human shape” as the lowest-level constituent and add one more rule to describe the process form “Human shape” to the previous “lowest-level constituent”.



Figure 7. The “Human shape” in the motifs

4. New grammar for ice-ray

In this section, we will define the new shape grammar rules for the ice-ray design and use them to describe the making process of a Chinese lattice design that cannot generated by existing shape grammar rules.

4.1. THE NEW ICE-RAY GRAMMAR

Our grammar contains two shape rules:

- **Rule1.** Put a hexagon in the centre.
- **Rule2.** Create “Human shape” by adding a bar on existing one.

For the rule1, the hexagon can be replaced by a triangle....The aim of this rule is to create “XuanJi” in the window pattern.

For the rule2, the length and angle of the adding bar vary in different situations.

The difference between our rules and Stiny’s is on the understanding of the design intention embedded in the ice-ray. When Stiny examined the ice-ray designs, he followed Dye’s understanding of the lattice design.

“In the case of the ice-ray pattern, [the artisan] divides the whole area into large and equal light spots, and then subdivides until he reaches the size desired; he seldom uses dividers in his work.”(Dye, 1949, page 17)

Stiny (1977) illustrated the design intention behind the ice-ray design as the following: “One can image a Chinese artisan, summoned to a building site; bring with him tools and implements and a collection of finely finished sticks. Shown a rectangular window frame, he is asked to create an ice-ray lattice. He begins his design by selecting a stick of the appropriate length and carefully attaching it between two edges of the existing rectangular frame...”

What Dye and Stiny described is the making process of the ice-ray lattice. The design intention embedded in it might vary. From the cultural hints we mentioned before, we can get a different understanding form the same making process. We can image the artisan’s intention is not to divide the areas but to add a bar to create the “Human shape” and for balance and aesthetics, he tries to keep the appropriate size.

4.2. VALADIATION OF NEW GRAMMAR

To validate our shape grammar rules, we will use them to generate the lattice window in the Figure 8. (The “bars” in the ice-ray designs are represented as single straight lines)



Figure.8. A Chinese lattice window from existing building

In the first step, the pentagonal shape is added in the centre of the window. Then, the “Human shape” is generated in the first layer. The whole process is

shown in Figure 9.

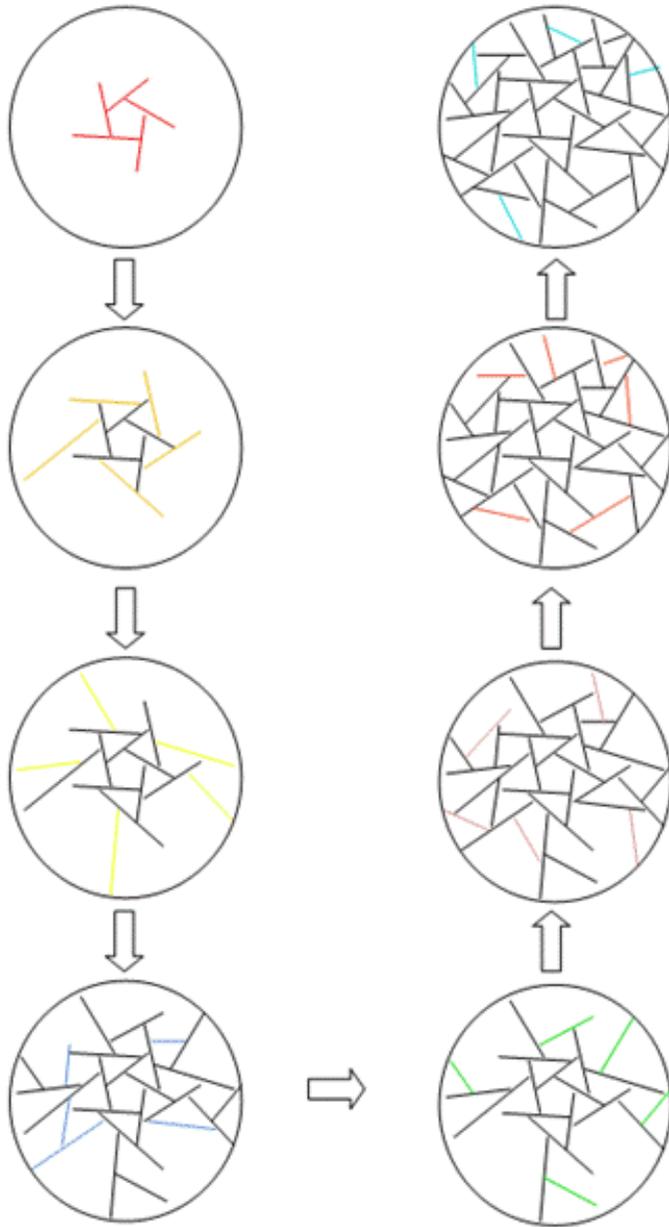


Figure.9. The generating process of by using new ice-ray rules

5. Discussion

In this paper, we try to describe the ice-ray designs by new shape grammar rules. We argue the inaccuracy of Dye's understanding on Chinese ice-ray design and propose new perspective to appreciate it by utilizing the related cultural information. Based on our understanding of the ice-ray design, we clarify the design intention embedded in it and develop our shape grammar rules follow the design intention. We validate our shape grammar rules by utilizing them to generate the ice-ray design.

Design intention plays a very vital role when we define the shape grammar rules. But sometimes it is difficult to clarify the ambiguous design intention of some artefacts because of the lack of literature. The cultural context can be utilized as hints to discover the design intention embedded. The concept of human and nature is very important in Chinese traditional culture and it can be found everywhere in the ancient Chinese artefacts. So we argue that the design intention of ice-ray is to build "Human shape" by two bars inside the window.

We demonstrate the process of generating the window by new shape rules. In the future, we will focus on the computer implementation of our shape grammar rules.

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