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by Irma Desiyana

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Shape Grammar for Cane Webbing Design

Irma Desiyana[1,*]

[1] *Department of Architecture, Faculty of Art and Design, Universitas Multimedia Nusantara, Tangerang, Indonesia*
[*] *Corresponding author. Email: irma.desiyana@umn.ac.id*

ABSTRACT
Shape grammar for cane webbing design is the way of seeing and doing it. The utilization of cane webbing, which is usually for furniture design, has potential use in the implementation of architectural design. When traditional handcrafters make cane webbing on a plane of furniture, the design can be generated and developed into a more complex architectural form. Shape grammar unfolds the possibility of exploring creativity in the design process and computational thinking. Hence, this research explores cane webbing from two-dimensional planes into three-dimensional forms. In this paper, the three-dimensional must have at least two planes where the application of cane webbing is attached to the plane. The first step is defining shape relation and shape rules of cane webbing design on a plane. After we determine the cane webbing grammar, we can apply it into a three-dimensional form, which opens possibilities and creativity for architectural design. In the end, this paper aims to combine craft and digital ways of cane webbing design into architectural design applications using shape grammar.

Keywords: *Shape grammar, Cane webbing, Computational design.*

1. INTRODUCTION

Crafting and computing have different usage tools; crafting uses a hand to make things, and computing is an act to make things by computer, machine, software, and digital fabrication. Shape grammar bridges crafting and computing by extracting and generating initial shape and shape rules. Cane webbing, a craft, is usually from rattan made by hand, and it has a specific pattern (see Figure1) that can generate utilizing shape grammar.

Figure 1 Cane webbing design.

Shape grammar, a computational design theory, was found 50 years ago. Stiny and Gips originally formulated it in 1972 to generate design formalism using shape [1]. In 2006, Stiny proposed that shape grammar is the act of seeing and doing [2]. Years later, shape grammar is not merely seeing and doing, but it is sensing and doing using stuff or wide-range materials to produce a thing or object design [3].

Meanwhile, cane webbing is a woven fabric for furniture by weaving it. Weaving is different from modular design, and making grammar generates a comparable set of designs [4]. Using shape grammar for cane webbing design is as same as seeing, doing, and sensing activity for craft and computational design. Designing with shapes is distinct from symbols and mathematics; however, it has rules to calculate [2]. Therefore, cane webbing design can elaborate with digital thinking by triggering creativity for architectural design.

2. SHAPE GRAMMAR IN ARTS AND ARCHITECTURE

Shape grammar is a generative formalism that generates and operates shapes with rules into the design. It supports shape exploration and adopts a fixed structure [5]. In computational design, it works as a representation of visual structures where repeated application rules on shape generate designs [5]. On the other hand, shape computation formalizes a structure of parts and produce new shapes through transformations

[6]. Shape grammar has been implemented in arts and architecture, such as Suakin's grammar [7], painting and sculpture grammar [1], Mughul Garden's grammar [2,8], Mamluk geometry [9], Kolam grammar [4], and many others. Thus, the utilization of shape grammar is for analytical approach, analytical and design approach, and design approach both in arts and architecture [10].

In early work, shape grammar aims to analyze and recompose arts. Visual arts employ shape generation using shape grammars on two-dimensional painting and three-dimensional sculpture [1]. Painting and sculpture have geometrical repetition generated by the initial shape and applying the shape rules [1]. The decomposition of shape and rules has put the foundation to generate modular painting and sculpture in computational design.

Moreover, the shape grammar is for architectural analytical and design approaches. The formal composition of the Suakin traditional houses exerts the generative model of shape grammar [7]. The corpus of the house, such as geometric, topological pattern, dimensional, and the shape rules ac as the language [7]. Each architectural element translates into Suakin vocabulary elements based on modular shapes and Suakin spatial relations [7]. It has proved that shape grammar as a generative process can analyze shapes and aspects of Suakin designs [7]. In another case, basic principles in Islamic geometry generate using the shape grammar approach [9]. The utilization of shape grammar is a rule-based geometry that focuses on vocabularies, spatial relationships, parameters, attributes, rules, transformation, and initial shapes [9]. From the analysis of existing design, shape grammar can reveal rules in parametric software [9]. From previous arts and architectural cases, shape grammar focuses on modular shape and repeated composition.

When a design is an activity solving problems, the designer should comprehend the problem and rules of design. The exact rule formation of shape grammar defines the understanding of design problems [11]. Seeing or recognizing parts and moving to transformation parts aim to understand the complicated structure [6]. Stiny has argued that design is seeing and doing by calculating shapes [2]. Stiny and Knight have added doing and sensing to develop making grammar [3,4]. Knight has made a new computational theory, making grammar, that open possibility to study craft practice. Shape rules in computations require seeing and doing [4]. Hence, a doing rule represents a physical change of a thing through physical activity [3,4]. A sensing rule represents a perceptual change in a person through sensory action with a thing [3,4]. As an action, doing is possible done by a person or a machine. Shape grammar is easier to make by hand (seeing and doing) [3]. Stiny and Knight explain the terms of stuff and things in making grammar [3]. Stuff implies materials with properties, and things constitute finite objects made of the stuff [3].

3. SHAPE GRAMMAR METHODS

This paper uses shape grammar to extract and recompose cane webbing design. Originally, Stiny and Gips proposed some stages of shape grammar, such as initial shapes, shape relations, shape rules, and designs [1,10]. However, it is hard to define those stages without understanding the design. The first step is observing (seeing) the cane webbing design to comprehend how its pattern correlates and formulates. To understand it is sensing and doing stuff by hand-drawing to make a cane webbing design. Then, we begin to generate it based on stages of shape grammar. Finally, we can examine cane webbing shape grammar by crafting and computing.

4. SHAPE GRAMMAR FOR CANE WEBBING DESIGN

4.1. Comprehending Cane Webbing Design

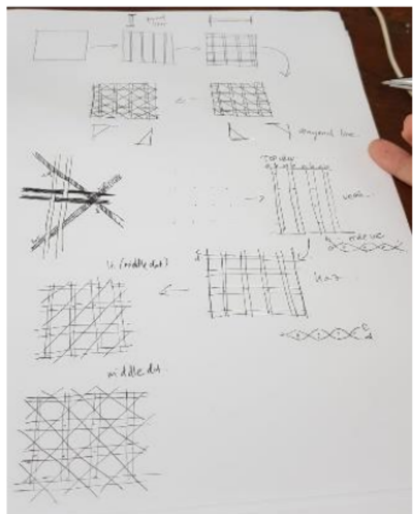

Figure 2 Experimenting (drawing) cane webbing grammar by hand.

Before decomposing cane webbing design, the act of observing and seeing (see Figure1) are crucial to understanding design. Then, drawing it in two-dimensional shapes makes imitating cane webbing design easier. Drawing by hand is helpful as an early step to make shape grammar (see Figure2). The lack of drawing is on a two-dimensional plane, though cane webbing, part of weaving, requires three-dimensional working space.

4.2. Stages of Shape Grammar for Cane Webbing Design

4.2.1. Initial Shape

The initial shape for cane webbing design is the line, where it is possible to use things or different kinds of material. The line length follows the need for design, where shape rules determine the design. The lines with material (thing) are the foundation to make cane webbing design (stuff). In the end, materials or things will give volume to the line (see Figure 3).

Figure 3 Initial shape.

4.2.2. Spatial Relations

The spatial relations between the lines have two conditions: double or parallel lines on the vertical and horizontal axis and a single line on the diagonal axis. The dots are benchmarks for the location and number of the lines. Furthermore, the dash lines stand for the vertical, horizontal, and diagonal axis. The intersection between the lines happens when each line overlaps the other (Figure 4).

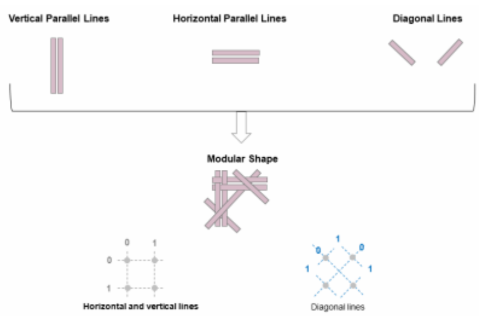

Figure 4 Spatial Relations.

4.2.3. Shape Rules

Shape rules for cane webbing design must operate in three-dimensional working space; consequently, the room for shape rules works on the x, y, and z-axis. The depiction of shape rules uses horizontal planes (x and y-axis) with top elevation and vertical planes with side elevation. As previously mentioned, there are dots and dash lines complete to assist the shape rules. The composition of dots is grid labelled 0 and 1 (see in Figure 5).

The distance between the guiding lines elucidates the length of the lines, and the position of the guiding lines explicate the type of the lines (horizontal-vertical parallel lines or diagonal line). When the guiding lines are parallel or facing each other, they become the starting and ending point for the vertical or horizontal parallel lines And, the guiding lines become the starting and ending point for diagonal lines if they form a corner. The angle of the corner varies along with the needs of the design.

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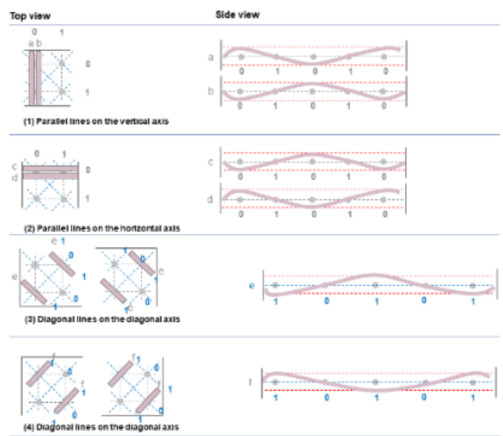

Figure 5 Shape rules for cane webbing.

The first rule is vertical parallel lines (a and b) intermittent with vertical grid axis (horizontal plane – top view) following the horizontal guiding lines. Line a and b always touch dot 1 on the vertical plane. Line a is on the top of dot 0, and line b is on the bottom of dot 0 (side view). The position of lines a and b will turn each other on the dot 0 (side view). Lines a and b only fill vertical grid axis number 0 or skip 1 vertical grid axis number 1.

The second rule is horizontal parallel lines (c and d) intermittent with horizontal grid axis (horizontal plane – top view) following the vertical guiding lines. Line c and d always touch dot 1 on the horizontal plane. Line c is on the bottom of dot 0, and line b is on the top of dot 0 (side view). The lines c and d will turn each other on the dot 0 (side view). Lines c and d fill horizontal grid axis number 0 or skip 1 horizontal vertical grid number 1.

The third rule is the diagonal line (e) intermittent, with the diagonal grid axis following the corner guiding lines on the horizontal plane. Line e is in the middle of the intersection of the vertical and horizontal lines and always touch dot 0. Line e is on the bottom of dot 1, and line b is on the top of dot 1 (side view). The position of lines e will turn top and down on dot 1 (side view).

The final rule is the diagonal line (f) intermittent, with the diagonal grid axis following the corner guiding lines on the horizontal plane. Line f is in the middle of the intersection of the vertical and horizontal lines and always touch dot 0. Line f is on the top of dot 1, and line b is on the bottom of dot 1 (side view). The position of lines f will turn top and down on the dot 1 (side view).

In the end, each intersection of lines must not meet and follow 0 and 1 numbers. So, the intersection between lines ab and cd must not meet each other. Indeed, lines e and f must not touch each other too. The different starting points have a purpose, so lines e-f (begin with axis-1) and ab-cd (begin with axis-0) will interweave each other to create cane webbing design detail.

4.2.4. Cane Webbing Design

Shape grammar decomposes the shape and rules of cane webbing design; then, it allows to compose cane webbing design in craft and computation design. The repetition of the parallel lines, the shape rules, happens only on grid 0, both vertical and horizontal. The meeting points between lines ab and cd are according to shape rules; therefore, there will be no collide lines. Afterwards, the making of cane webbing design follows some steps, including (see in figure 6):

1. the parallel lines on the vertical axis,
2. the parallel lines on the horizontal axis,
3. the diagonal lines on the diagonal axis, and
4. the opposite diagonal lines on the diagonal axis.

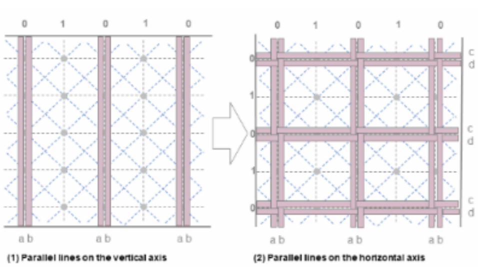

Figure 6 The making of parallel lines on the vertical and horizontal axis.

The next step is making diagonal lines on the diagonal axis number 1. The rules are similar and valid for the same and opposite diagonal lines. Finally, shape grammar has successfully analyzed and generated the logic and formula of cane webbing design (Figure 7).

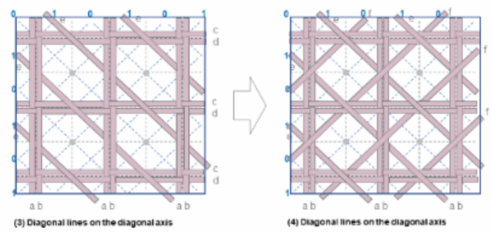

Figure 7 The making of diagonal lines on the diagonal axis.

4.3. Examining Shape Grammar for Cane Webbing Design

Composing cane webbing design using shape grammar support the experiment to make webbing design from rattan. The writer follows similar steps from cane webbing grammar. Rattan (stuff) has excellent flexibility when it contains water; hence, it will break into pieces if we try rattan to weaving. In the end, shape grammar simplifies the rules and steps of making rattan webbing designs (things) (Figure 8).

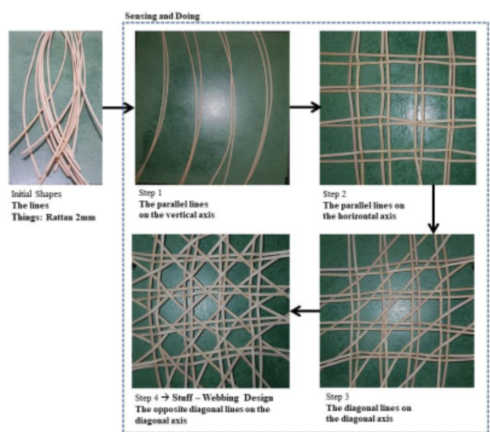

Figure 8 Weaving with rattans (the lines – stuff) to make webbing design (thing).

5. CONCLUSION

Even though this research has put the foundation of computational thinking of cane webbing design, it needs further works on computational design. Shape grammar, a design formalism for craft and digital computation, can develop more on different forms of things and various stuff or materials. Crafting product, cane webbing design, can be generated with shape grammar by seeing (observing) and doing (experimenting). Dismantling cane webbing designs has created a formulation or rules of design with stuff into a thing. The stages in shape grammar help analyze the existing design and explore new possibilities of the new design. Furthermore, original shape grammar is finite and easy to modular and repeated shape; thus, it becomes a challenge to research irregular shapes.

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