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Coordinate-Parametric Matrix Model Inspired Square-Conjoint Pattern in Cross Woven for Conventional Bamboo Mat

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Received: 19 December 2022 Accepted: 07 February 2023 Published: 10 November 2023

ABSTRACT

In the study, it is proposed that a coordinate-parametric matrix model is performed to a square-conjoint pattern of cross woven (SCPCW) in the bamboo mat. The patterns of SCPCW are firstly detected according to the perspective of configuration, which is divided into the basic-monomer shape and the basic combination shape. Secondly, the compositions of design patterns in SCPCW are analyzed to attain the trend of curve shape. Based on the coordinate-parametric matrix model, the specimens of SCPCW are subsequently accomplished to elaborate the woven logic of bamboo mats. The digital innovation of SCPCW, defined by a mathematical resolution, is implemented by the software of Grasshopper (GH), which plays a crucial role in capturing image information by the Image Sampler component. Successively, the weaving logic of coordinated matrix is referred to apply in the computing component of Grasshopper software. Finally, the computer simulation could demonstrate that the coordinate-parametric matrix model of SCPCW would be realized to analyze the micro-weaving structure and overall weaving effect in the bamboo mat.

KEYWORDS

Cross woven; configuration and composition; coordinated parametrization; weaving model

1 Introduction

In the Asia-Pacific region, some conventional bamboo products are abundant [1–3], e.g., bamboo houses, bamboo furniture, bamboo ornamentation, bamboo necessities, and so on. It is especially prominent that bamboo weaving is inset into these bamboo productions. In architectural or furniture decoration, household products, and stationery, bamboo wovens could be sought because the bending strength of the bamboo is applied to weave in various ways [4–9]. Bamboo weaving techniques are classified as polygonal woven and cross-woven [10–12]. The unit of the polygonal-woven pattern (Fig. 1a) is often constructed by three or more bamboo strips (Figs. 1b and 1c), which are interwoven via several angles to make a hollow polygonal-woven structure. However, a single-geometric shape is only anchored into the polygonal-woven pattern (Figs. 1b and 1c). The cell of the cross-woven pattern (Fig. 1d) is made up of two bamboo strips vertically interwoven to pick and press between the warp direction and the weft direction (Fig. 1e). Consequently, a cross woven could emerge many rectangular



blocks (Fig. 1d) in a bamboo mat pattern [9,12]. Hence, the cross-woven bamboo design is comparatively applied in furniture and fixtures, specially constructed sophisticated woven patterns [11]. The quadrilateral-chambray mat is composed of some continuous shapes, which are arranged in the bamboo as follows connected type, scattered type, and overlapping type [13]. Usually, a basic shape is centered in the mat pattern to obtain the emissive-decoration effect [14]. Among them, the connected type of square-conjoint pattern is regarded as simple, single, or multiple-constituent patterns, which can be fabricated the visual image in a harmonious and comfortable atmosphere by means of arrangement and repetition [15]. SCPCW in the bamboo mat could be more easily architectural aesthetics, which is more and more popular in decorative applications of household products [11,14,16].

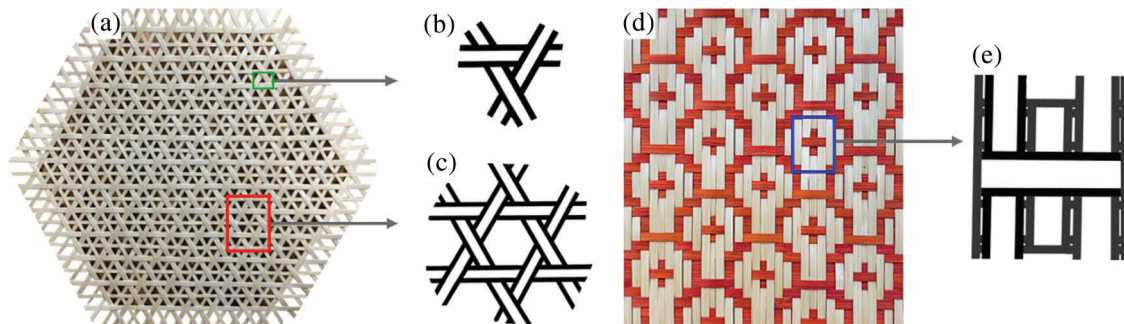


Figure 1: Polygonal and cross-woven structure: (a) Real bamboo mat by the polygonal-woven style. (b) Polygonal-woven structure I. (c) Polygonal-woven structure II. (d) Real bamboo mat by the cross-woven style. (e) Cross-woven structure

Many brands have popularized the design elements of woven bamboo due to their natural material texture, woven patterns, color matching, and other aesthetic values [16]. The Japanese Nendo studio has released the Tokyo Tribal Collection of woven bamboo and wooden furniture products [17]. Swedish IKEA has launched the MISTERHULT woven bamboo lighting and home product line [18]. The French clothing brand, CHANEL, has even released a woven bamboo handbag [19]. Several interesting furnishings embellished with bamboo weaving were displayed during the 2022 Milan Design Week [20,21] by the Spanish leather goods company LOEWE, the French luxury brand LOUIS VUITTON, etc. These anecdotes confirm that the bamboo weaving collection has a strong international market value. Therefore, the diversification of bamboo weaving is more and more important in fostering a novel design fabrication [22,23]. The adjustment could spontaneously arise in the process if the actual weaving effect can not satisfy the designer's expectations [22,23]. However, the amendment during the design and process is very complex and different. It is well known that bamboo weaving is a traditional handicraft, with the weaving process being temporal, geospatial, lingual, and cultural limitations [22–26]. The communicated obstacles between the artisan and designer should be removed in an intuitive way [22–26], then the bamboo weaving would be preferably applied in modern life.

There are a lot of digitized and visualized means to help designers preview partial woven structures and holistic aesthetic effects [27,28], such as Autodesk's 3ds Max, Maya design programs, CorelDRAW's Rhinoceros, and so on. As previously mentioned, some heavily regular orderliness and intricate structural logic are investigated in the pattern compositions of woven bamboo. Although these aforementioned modeling tools could be performed in the structure of woven bamboo, their fundamental methods are tremendous and inefficient [27,28]. The parametric design concepts are first applied in architecture, such as Antonio Gaudi's the Sagrada Família, Zaha Hadid's the Circle at Zurich Airport exhibition hall in Germany, Ma Yansong's the Absolute Towers, and so on [29]. The

complex structural systems perform a parametric design to quickly accomplish the design intent by controlling some variables in a three-dimensional workspace, such as points, lines, and surfaces [30–33]. GH is developed by implanting the algorithm plug-in for Rhino to address many problems encountered in the parametric design cycle of architecture by extending the program to achieve more parametric functions [29–31].

In this study, the dogtooth pattern and the fish-style pattern of SCPCW will be investigated by the coordinate-parametric matrix model, configured by the basic-monomer shape and basic-combination shape, respectively. It could be reinterpreted woven logic of SCPCW through the coordinate sequences of the bamboo mat. Compared to bamboo weaving and jacquard fabric, the image information is likewise digitalized to realize the freely desired effects. Namely, the matrix coordinate of the bamboo mat pattern is similar to the digital weaving software of the jacquard fabric [34–36]. Subsequently, the gradients of the weaving units in the bamboo-mat description can be adjusted and regulated for some weaving textures in various patterns [27,28,37]. Actually, the coordinate-parametric matrix model can be attained by the coordinate image of the floating point pixel in the Image Sampler component of the GH. Finally, the designers can lightheartedly discern and review the effects of the bamboo-mat pattern by installing this coordinate-parametric matrix model, which can be freely restructured and modified until getting a satisfied prospect [29–31].

2 Composition Form of SCPCW in the Bamboo Mat

A basic shape is the unit of pattern in a bamboo mat, which can be divided into two forms, namely monomeric and duplex-style shapes. The primary skeletal framework of basic shape is made up of visible and invisible lines or geometric shapes. The skeleton-framework joints are seamless and can be continuously stretched toward four directions-top of the woven bamboo mat [13]. In this way, a visual impression of the bamboo-mat pattern can be displayed, which is the regular effect of unity, proportionality, repetition, and continuity. The explanatory subsections would be elaborated to better understand this concept.

2.1 Configuration of Basic Shapes in SCPCW

Fig. 2a describes a picture of real products decorated with a dogtooth pattern in the bamboo mat. The basic-monomer shape of SCPCW in the bamboo mat is shown in a dogtooth pattern, which is a single geometric shape in an independent form (Fig. 2b). The variational cluster of a basic-monomer shape is exhibited in Figs. 2c–2h. In bamboo mats, some prospects of the SCPCW are configured by a single monomer. Others are configured by the combination of two or more monomers. The graphic rule of variational clusters to the basic monomer shape is investigated as follows in Fig. 2: the dogtooth pattern of Fig. 2b is regarded as the original monomer. The monomer is horizontally flipped in Fig. 2c. The monomer is vertically flipped in Fig. 2d. The monomer is rotated 180° in Fig. 2e. Furthermore, these monomers can be dynamically arranged to some of the basic-combination shapes of the SCPCW in Figs. 2f–2h. It is explored that the monomer is gyrated, deconstructed, and rotationally reorganized, respectively.

In Figs. 2f–2h, these basic-combination shapes are produced by recomposing the same initial basic shape, which is transformed at the quantitative locations and angles. The basic-combination form is also possible to be created by two or more distinct morphologies (Fig. 3a, a fish-style pattern). In Fig. 3b, it is seen that two monolithic geometries of different shapes are juxtaposed along the center axis. After that, it is inspected that a monolithic pattern is made up of two basic-combination shapes.

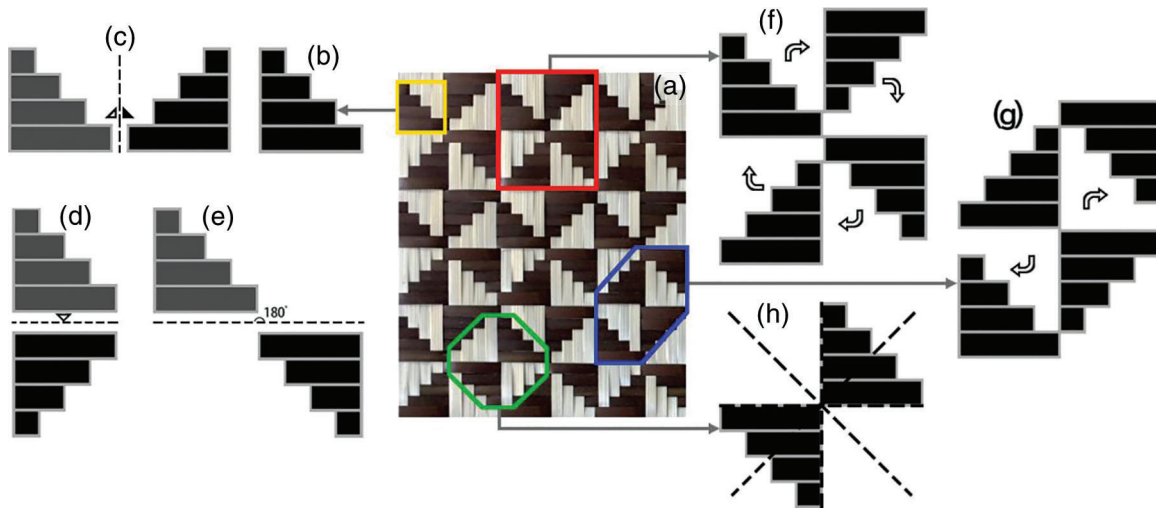


Figure 2: Variational-cluster representations of the basic-monomer shape in SCPCW bamboo mat: (a) Picture of real bamboo mat filled by the dogtooth pattern of SCPCW. (b) Dogtooth pattern. (c) Basic-monomer shape I. (d) Basic-monomer shape II. (e) Basic-monomer shape III. (f) Basic-combination shape I. (g) Basic-combination shape II. (h) Basic-combination shape III

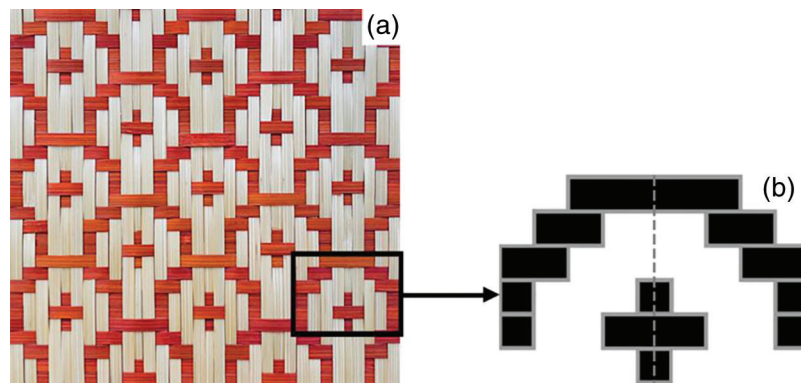


Figure 3: Multi-body configuration representations of the SCPCW in bamboo mat: (a) Picture of real bamboo mat filled by the fish-style pattern of SCPCW. (b) Basic-combination shape

2.2 Composition of SCPCW in the Bamboo Mat

From different viewpoints, the continuous patterns of SCPCW are regarded as varied apperceptions [13]. Then, some tendencies of skeleton frameworks are observed, which can indicate the continuous patterns stretching across these different basic shapes. SCPCWs in the bamboo mat can be distinguished into linear and geometric skeletal frameworks (Fig. 4). In Figs. 4a–4c, the dogtooth pattern is formed by the skeletons framework of quadrilateral, hexagonal, and polygonal shapes to form three new basic-combination shape units, which are the skeletons framework of these basic-combination shape units are then repeatedly arranged in four directions in a juxtaposed or step-type to enhance the visual recognition and awareness of the basic-combination shape units. In addition, the fish-style patterns in Figs. 4d–4f are repeatedly continued in four directions through three different linear skeletal frameworks of linear equidistance, the diagonal-conjoint, and the wavy curve, respectively, thus forming a visual identification and awareness of the fish-style patterns. Hence, the visual impact of SCPCWs can enhance pattern identification and awareness [13,15].

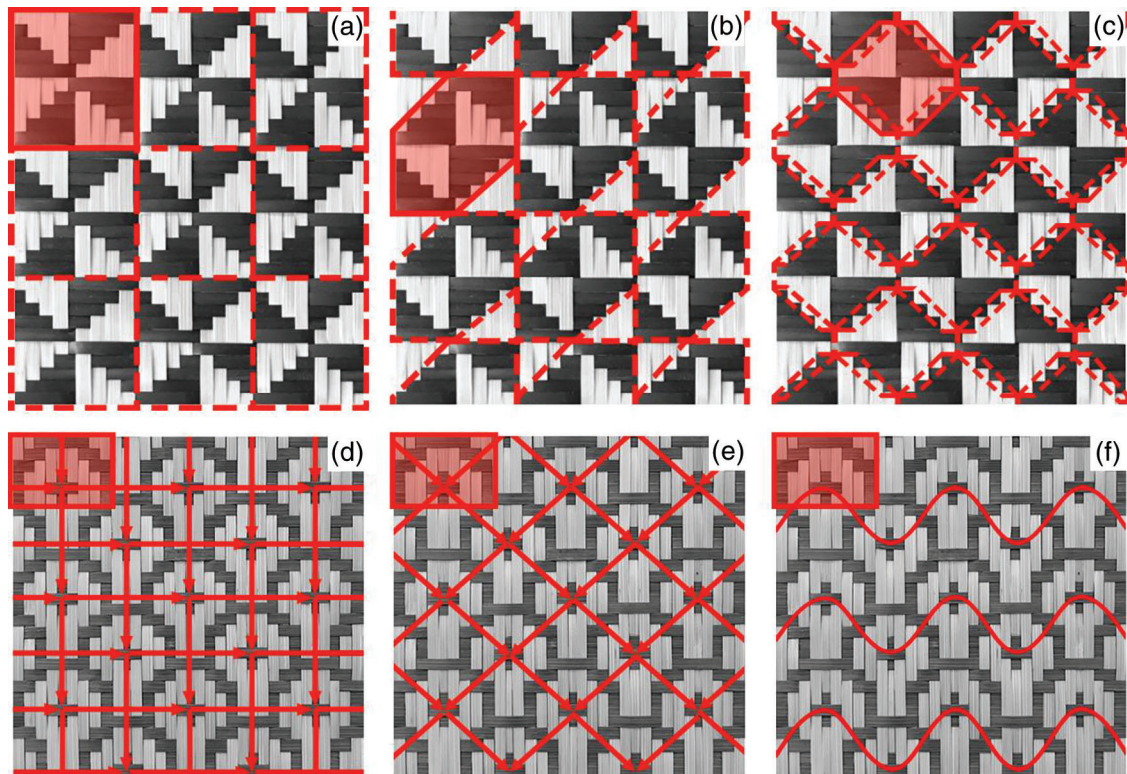


Figure 4: Skeletal frameworks representations of SCPCW in bamboo mat: (a) Geometric skeletal frameworks I. (b) Geometric skeletal frameworks II. (c) Geometric skeletal frameworks III. (d) Linear skeletal frameworks I. (e) Linear skeletal frameworks II. (f) Linear skeletal frameworks III

3 Coordinate and Parameters of SCPCW in the Bamboo Mat

3.1 Elements of Model Building to the Bamboo-Mat Pattern of SCPCW

The longitudinal strips picked and pressed in the cross-woven bamboo mat are known as warp strips, while the horizontal strips weaved in sequence are known as weft strips [10,11,38,39]. In the cross-woven bamboo mats, warp strips and weft strips are perpendicularly intersected and woven into the bamboo, which could fabricate the effect of a rectangularly geometric block [12,40]. The gaps between the warp strips and weft strips are arranged in a quadrilateral pattern [40], where the cross-section structures are presented in a wavy pattern [28]. In the bamboo mat, several color strips can be sought, namely a dyed strip and a nature-color strip [39]. In that way, these polychrome bamboo strips can make a tremendous visual impact. Usually, the colored strip is employed as a weft strip. The natural strip is applied to a warp strip. In this study, if the weft is pushed above the non-dyed warp strips to regard as a positive pattern, other than if the colored strip is pressed below the non-dyed strip it regards as a negative pattern. To rapidly capture pictorial information of woven patterns, a recognition of colour design on the bamboo mat is defined as the black-and-white grid pictures, which is analogous to a binary image matrix division construct [35,36,41].

In Fig. 5, a vertical column is represented by a warp strip, and a weft strip represents a horizontal row. Hence, a matrix coordinate system of each block containing positive or negative shape information is modeled. Dogtooth (Fig. 5a) and fish-style (Fig. 5c) patterns are converted into binary representations (Figs. 5b and 5d), respectively, in which the positive and negative shapes of the patterns are sequentially filled with black and white rectangles. As to the binary matrix, the parameters of P and N have denoted the coordinate array of the positive and negative shapes in the pattern, respectively.

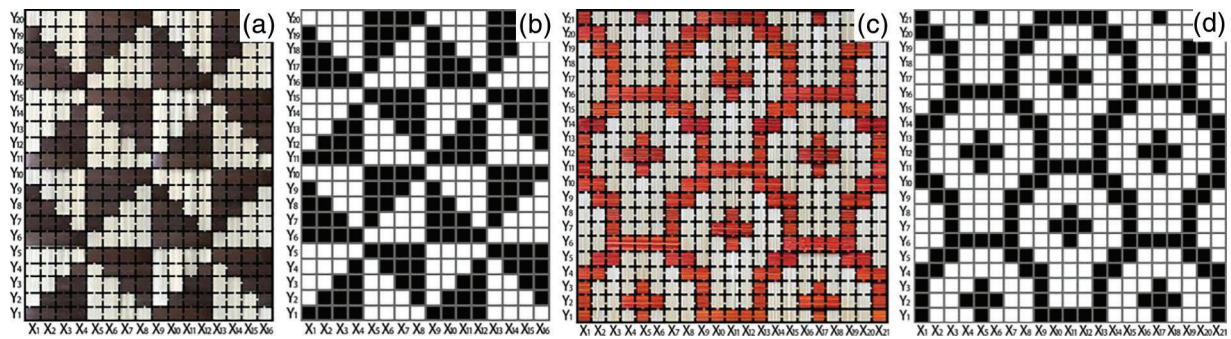


Figure 5: Binary representations of matrix coordinates of SCPCW bamboo mat: (a) Picture of real bamboo mat filled by the dogtooth pattern of SCPCW. (b) Binary matrix coordinate image I. (c) Picture of real bamboo mat filled by the fish-style of pattern SCPCW. (d) Binary matrix coordinate image II

In the practical performance, the minimum width and thickness of the strip in the weaving bamboo mats are 1.5 and 0.1 mm, respectively. In the study, the design of the weaving model is conducted with bamboo strips of 1.5 mm width and 0.1 mm thickness. It is explored that the uneven surface of the bamboo mat would emerge if a weft strip is sequentially weaved in 7 warp strips (Fig. 6a) [12,42]. The elasticity modulus of the bamboo strip could possibly generate this phenomenon. Thus the variates of the binary matrix are maximized up to 7, which are the parameters in the vertical column and horizontal row. In this study, the matrix coordinates of the basic-monomeric and basic-combination shapes are selected as examples to supervise standardized weaving.

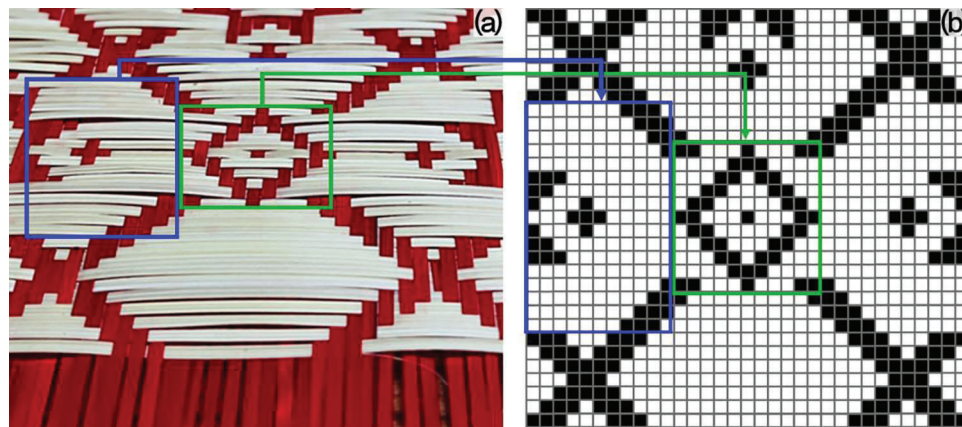


Figure 6: Unit lengths representations of strip picking and pressing in cross-woven bamboo mats: (a) Picture of the real bamboo mat by the cross-woven. (b) Binary matrix image

The coordinate array C in Eq. (1) [41,43] is represented the bamboo mat of SCPCW based on the binary matrix:

$$C = \begin{bmatrix} (X_1, Y_h) & \cdots & (X_w, Y_h) \\ \vdots & (P, N) & \vdots \\ (X_1, Y_1) & \cdots & (X_w, Y_1) \end{bmatrix} = \{(X_1 \sim X_w, Y_1 \sim Y_h)\} \tag{1}$$

where X is the warp strips of woven bamboo, Y is the weft strips of woven bamboo, X_w represents the variable of the warp strips of woven bamboo, Y_h represents the variable of the weft strips of woven bamboo, P is the

positive shape coordinate, and N is the negative shape coordinate. As construct C combines positive and negative shapes, the patterns in the matrix take values in the vertical direction from left to right as X_1, X_2, \dots, X_w and in the horizontal direction from bottom to top as Y_1, Y_2, \dots, Y_h .

Based on C , the matrix coordinate arrays of P and N (Eq. (2)) corresponding to the positive and negative pattern shapes can now be established:

$$[(X_s, Y_h), \dots, (X_{s+a}, Y_h)] = \{(X_s \sim X_{s+a}, Y_h) | s \geq 1, 0 \leq a \leq 6, h \geq 1\} \tag{2}$$

where X is the warp strips of woven bamboo, Y is the weft strips of woven bamboo, Y_h represents the variable of the weft strips of woven bamboo, X_s is the starting warp variable, and subscript a is the pattern-width increment. The rectangular coordinates of the pattern's positive or negative shape information in the horizontal Y_h matrix take values in the range of $X_s \sim X_{s+a}$.

3.2 Coordinate Matrix of Monomer Shape

According to Eq. (2), Eq. (3) represented the coordinate array of positive shapes is deduced to illustrate the dogtooth pattern, which is exemplified by the basic-monomer shape $C_{DT} = (X_1 \sim X_4, Y_1 \sim Y_5)$ in Fig. 7 as following:

$$P_{DT} = \begin{bmatrix} P_4 = (X_4, Y_4) \\ P_3 = (X_3 \sim X_4, Y_3) \\ P_2 = (X_2 \sim X_4, Y_2) \\ P_1 = (X_1 \sim X_4, Y_1) \end{bmatrix} \tag{3}$$

where P_{DT} is the coordinate matrix of positive shapes of the dogtooth pattern, X is warp strips of the positive shapes, and Y is weft strips of the positive shapes.

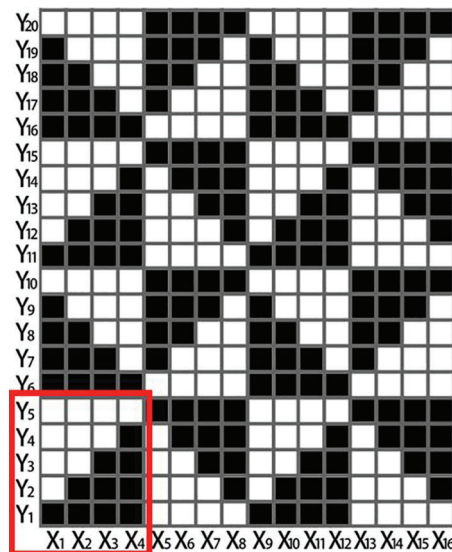


Figure 7: The schematic of binary matrix coordinate to dogtooth pattern

In the same way, the coordinate array of negative shapes in the dogtooth pattern is reflected in Eq. (4):

$$N_{DT} = \begin{bmatrix} N_4 = (X_1 \sim X_4, Y_5) \\ N_3 = (X_1 \sim X_3, Y_4) \\ N_2 = (X_1 \sim X_2, Y_3) \\ N_1 = (X_1, Y_2) \end{bmatrix} \tag{4}$$

where N_{DT} is the coordinate matrix of negative shapes of the dogtooth pattern, X is warp strips of the negative shapes, and Y is weft strips of the negative shapes.

According to Eqs. (3) and (4), Eq. (5) represented the coordinate array of the combination of positive and negative shapes in the dogtooth pattern:

$$C_{DT} = \begin{bmatrix} N_4 \\ (N_3, P_4) \\ (N_2, P_3) \\ (N_1, P_2) \\ P_1 \end{bmatrix} \quad (5)$$

where C_{DT} is the coordinate combination of positive and negative shapes of the dogtooth pattern, P is the coordinate matrix of positive shapes of the dogtooth pattern, and N is the coordinate matrix of negative shapes of the dogtooth pattern.

In the dogtooth pattern (Fig. 7), the $P_1 = (X_1 \sim X_4, Y_1)$ replaced the first to fourth rectangles is those black rectangles in the first horizontal matrix, which is explained the first weft strip pressing the first to fourth warp strip (i.e., press four strips). The $P_2 = (X_2 \sim X_4, Y_2)$ replaced the second to fourth rectangles are those black rectangles in the second horizontal column matrix, which is explained by the second weft strip pressing the second to fourth warp strip (i.e., press three strips). In addition, the $N_1 = (X_1, Y_2)$ replaced the first rectangles is white rectangles in the second horizontal column matrix, which is explained by the first warp strip picking atop the second weft strip (i.e., pick one strip). In the same way, the $N_2 = (X_1 \sim X_2, Y_3)$ is explained as the first two warp strips picking atop the third weft strip (i.e., pick two strips). According to the performance in pressed and picked of the coordinate-parametric matrix model, the P coordinate is revealed that Y is pressed on X , and the N coordinate is revealed that X is picked on Y (namely, P is regarded as “press” and N is regarded as “pick”).

3.3 Coordinate Matrix of Combination Shape

According to Eq. (2), Eq. (6) represented the coordinate array of positive shapes is deduced to illustrate the fish-style pattern, which is exemplified by the basic-combination shape $C_{FS} = (X_1 \sim X_9, Y_1 \sim Y_6)$ in Fig. 8 as following:

$$P_{FS} = \begin{bmatrix} P_6 = (X_3 \sim X_7, Y_6) \\ P_{5.1} = (X_2 \sim X_3, Y_5), P_{5.2} = (X_7 \sim X_8, Y_5) \\ P_{4.1} = (X_1 \sim X_2, Y_4), P_{4.2} = (X_8 \sim X_9, Y_4) \\ P_{3.1} = (X_1, Y_3), P_{3.2} = (X_5, Y_3), P_{3.3} = (X_9, Y_3) \\ P_{2.1} = (X_1, Y_2), P_{2.2} = (X_4 \sim X_6, Y_2), P_{2.3} = (X_9, Y_2) \\ P_1 = (X_5, Y_1) \end{bmatrix} \quad (6)$$

in the coordinate matrix, where P_{FS} is the positive shape of the fish-style pattern, X is warp strips of the positive shapes, and Y is the weft strips of the positive shape.

In the same way, the coordinate array of negative shapes in the fish-style pattern is reflected in Eq. (7):

$$N_{FS} = \begin{bmatrix} N_{6.1} = (X_1 \sim X_2, Y_6), N_{6.2} = (X_8 \sim X_9, Y_6) \\ N_{5.1} = (X_1, Y_5), N_{5.2} = (X_4 \sim X_6, Y_5), N_{5.3} = (X_9, Y_5) \\ N_4 = (X_3 \sim X_7, Y_4) \\ N_{3.1} = (X_2 \sim X_4, Y_3), N_{3.2} = (X_6 \sim X_8, Y_3) \\ N_{2.1} = (X_2 \sim X_3, Y_2), N_{2.2} = (X_7 \sim X_8, Y_2) \\ N_{1.1} = (X_2 \sim X_4, Y_1), N_{1.2} = (X_6 \sim X_8, Y_1) \end{bmatrix} \quad (7)$$

in the coordinate matrix, where N_{FS} is the negative shapes of the fish-style pattern, X is warp strips of the negative shapes, and Y is the weft strips of the negative shapes.

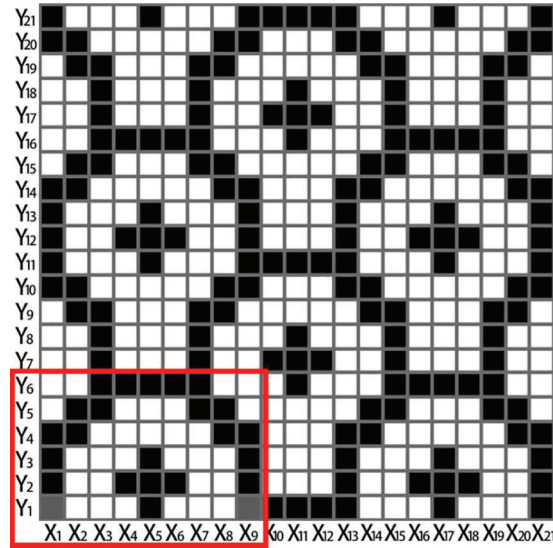


Figure 8: The schematic of binary matrix coordinate to fish-style pattern

In Fig. 8, it is seen that two geometries of different shapes are juxtaposed along the center axis, which is inspected as a monolithic pattern. Namely, the coordinates of the central axis in the pattern are $P_1, P_{2.2}, P_{3.2}, N_4, N_{5.2}$, and P_6 , respectively. After that, it forms multiple sets of symmetric matrices with the coordinates of the central axis. In the fish-style pattern, Eq. (8) represented the coordinate array of the positive and negative shapes indicated as follows:

$$C_{FS} = \begin{bmatrix} (N_{6.1}, P_6, N_{6.2}) \\ (N_{5.1}, P_{5.1}, N_{5.2}, P_{5.2}, N_{5.3}) \\ (P_{4.1}, N_4, P_{4.2}) \\ (P_{3.1}, N_{3.1}, P_{3.2}, N_{3.2}, P_{3.3}) \\ (P_{2.1}, N_{2.1}, P_{2.2}, N_{2.2}, P_{2.3}) \\ (N_{1.1}, P_1, N_{1.2}) \end{bmatrix} \quad (8)$$

in the fish-style pattern, where C_{FS} is the coordinate combination of positive and negative shapes, P is the coordinate matrix of positive shapes, and N is the coordinate matrix of negative shapes.

4 Perform a Parametric Simulation Modeled with GH to the Weaving Pattern of SCPCW

4.1 Coordinate-Parametric Transformation Logic of SCPCW

Especially, the weaving logic of the coordinated matrix is referred to apply in the computing component of GH software, which is realized to predict the micro-weaving structure and weaving effect in the bamboo mat. First, the bamboo-mat pattern is segmented to the binary image, similar to when a jacquard fabric's pattern matrix [34–36,43]. In fact, the Image Sampler component of GH could recognize the coordinate information of the SCPCW in the bamboo mat, which could recognize the array output of the jacquard pattern oppositely from the textile-information identification. The Image Sampler component can transform the image's color characteristics to the numerical digitization by floating-point pixel coordinates in the range [0,1], where a high brightness recognition of the output parameter is defined as 1, and a low brightness recognition of output value is defined as of 0. In Fig. 9, the Image Sampler component has separately gathered the lightness and darkness of the binary image in the dogtooth pattern (Fig. 9a) and

the fish-style pattern (Fig. 9c), which is referred the Eqs. (5) and (8). Successively, the parameter matrix (Fig. 9b) of the dogtooth pattern and the parameter matrix (Fig. 9d) of the fish-style pattern can respectively be obtained as follows. ‘ $P = 0$ ’ and ‘ $N = 1$ ’ are represented by the black rectangle (positive shape P) and the white rectangle (negative shape N).

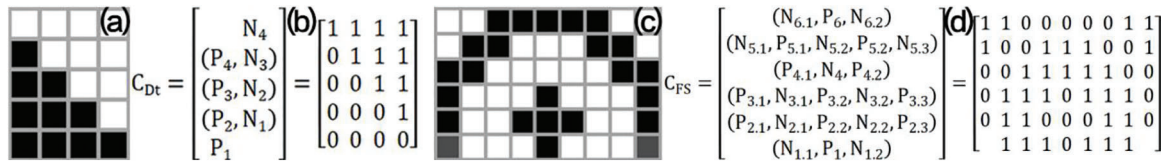


Figure 9: The schematic of binary and parameter matrix of basic shapes: (a) Binary matrix I. (b) Parameter matrix I. (c) Binary matrix II. (d) Parameter matrix II

4.2 Parametric Modeled of SCPCW Structure in the Bamboo Mats

In Table 1, it can be seen to indicate the parametric-modeling logic of the SCPCW in the bamboo mat, which is based on the coordinate weaving method, pattern coordinate-parametric transformation logic, and SCPCW composition form. Firstly, in the cross-woven bamboo mats, the warp strip and weft strip are perpendicularly intersected and woven, which are fabricated with the effect of a rectangularly geometric block [40]. Therefore, in the GH plug-in, the matrix parameters of $X \times Y$ in Figs. 10a and 10e can be input to form a 2D matrix lattices of $C_{DT} = X_{16} \times Y_{20}$ and $C_{FS} = X_{21} \times Y_{21}$, which realize the matrix space of the bamboo mats pattern (Figs. 10b and 10f). In 2D matrix lattices, lightness and darkness detection of the Image Sampler component in GH can be captured, which are the parameters representing the weaving structure’s nodes (Figs. 10c and 10g).

Table 1: Parametric arithmetic logic of SCPCW bamboo mat structure

Arithmetic logic	Structural components	Variable components
Build woven surface 2D grid framework; Pattern information collection	Square/Polygon Center/Image Sampler	Number slider
Build warp and woven nodes	Deconstruct/Construct Domain/Remap Numbers/Construct Point/Flip Matrix	Number slider
Build warp and woven interpolation curve	Interpolate	–
Build warp and woven surface	Perp Frame/Rectangle/Construct Domain/Negative/Extrude Along	Number slider

Secondly, the Z-axis value mapped for the image acquisition is input into the Image Sampler component to generate upward and downward altitudes floating on the 2D matrix lattices. Hence, the wave-like variation (Figs. 10d and 10h) of the warp strips and weft strips along the Z-axis can take shape on the cross-sectional surface [28] of the SCPCW bamboo mat. Thus, the black rectangle’s center will jump on the surface of the bamboo mat when the white rectangle’s center is kept still. Whereas the white rectangle’s center is going to grow tall when the black rectangle’s center is kept static. As a result, the 3D warp and weft weaving nodes of the dogtooth pattern (Fig. 10d) and fish-style pattern (Fig. 10h) appeared following the prescribed order.

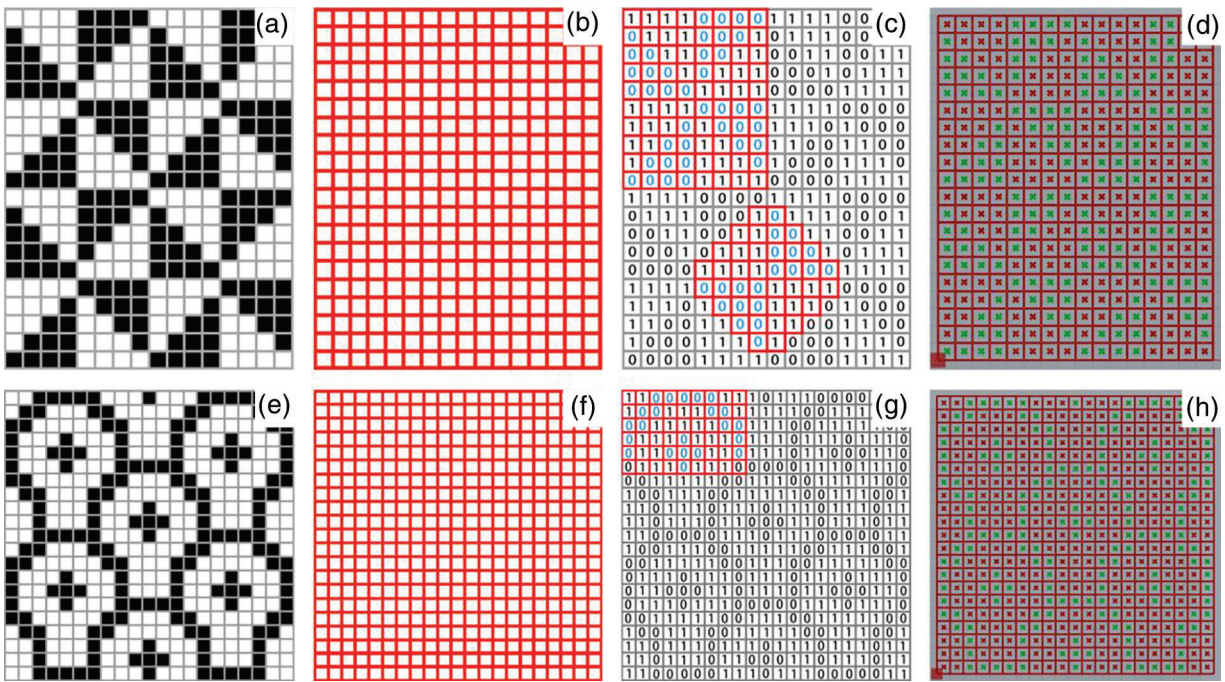


Figure 10: The schematic of binary and parameter matrix of SCPCW: (a) Binary matrix of dogtooth pattern in SCPCW. (b) 2D grid framework I. (c) Parameter matrix I. (d) Weaving Nodes I. (e) Binary matrix of fish-style pattern in SCPCW. (f) 2D grid framework II. (g) Parameter matrix II. (h) Weaving Nodes II

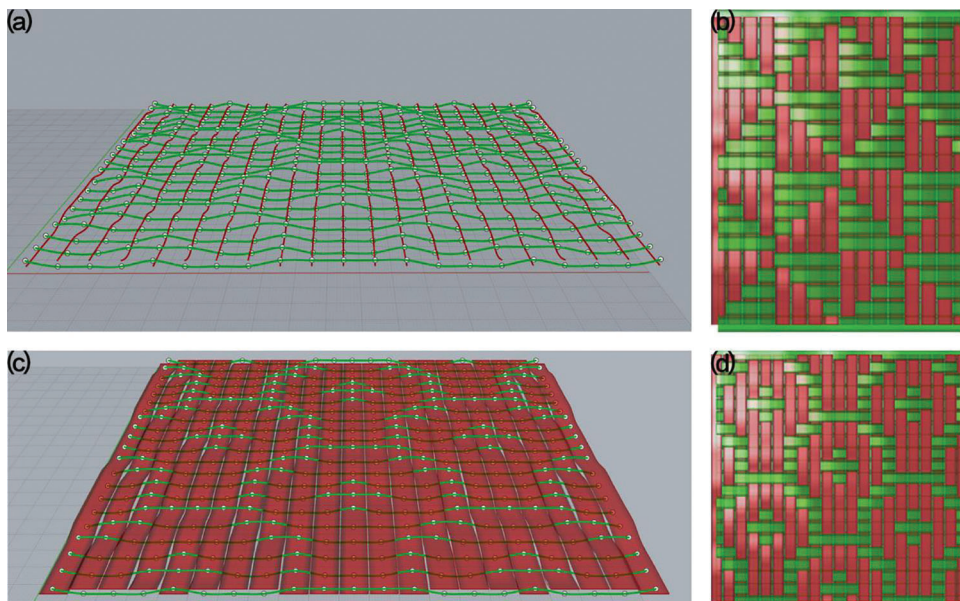


Figure 11: The schematic of parametric model schematic by the interpolation curves in GH plug-ins: (a) Woven interpolation curve I. (b) Parametric model I. (c) Woven interpolation curve II. (d) Parametric model II

Successively, the interpolation lines are pointed into after connecting some woven nodes along the warp direction, and the weft direction, respectively (Fig. 11a). Based on the centroid of the interpolation curves, the length, width, and thickness of the woven surface are arranged by customizing the parameter variables of the warp and weft woven surface. Afterward, the custom parameter squares extend along the interpolation curves in the warp directions and weft directions, which form an up-and-down interwoven woven surface (Fig. 11c). Finally, the parametric model of the SCPCW in the bamboo mat can be made as follows, the model of the dogtooth pattern (Fig. 11b) and the model of the fish-style pattern (Fig. 11d).

5 Conclusion

In order to realize the digitization of bamboo mats, a mathematical resolution has been substantially elaborated by extracting the configuration form and composition form of SCPCW in the traditional bamboo mat. In the future, parametric technology in bamboo mats will not only attain some diverse landscape designs but also efficiently fabricate beautiful bamboo decoration. In the project, some analyses have been presented as follows:

- (1) The image configuration of the cross woven in the bamboo mat could be explicitly defined as follows, the basic-monomer shape and the basic combination shape. At the same time, the compositions of design patterns in the bamboo mat of SCPCW are analyzed to attain the trend of curve shape.
- (2) The coordinate-parametric matrix model has been executed to inspire a digital analysis of the cross-woven delineation in a bamboo mat.
- (3) A computer simulation carried out by GH software could confirm that the coordinate-parametric matrix model of SCPCW in the bamboo mat would be effective.

Funding Statement: This work acknowledges the financial support from the Hunan Provincial Key Research and Development Program (2020WK2018); the Arts Crafts Industrial Design Center of Hunan Province (No. 2022GYMSZ2); and the Scientific Innovation Fund for Post-Graduates of Central South University of Forestry and Technology (No. 2022CX02079).

Author Contributions: Conceived and designed the experiments: Ye Fu, Jinbo Hu; performed the experiment: Ye Fu, Liwen Deng, Ting Li; supervised the work: Jinbo Hu, Shanshan Chang; wrote the paper: Ye Fu, Liwen Deng, Jinbo Hu; revised the paper: Jinbo Hu, Shanshan Chang.

Availability of Data and Materials: Data generated or analyzed during this study were included in this published article and its supplementary information files.

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

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