Abstract
For the Toraja, an ethnic group indigenous to South Sulawesi, Indonesia, ornamental engravings known as 'passura' form more than simple decorative elements on their local architecture—they are symbolic icons that convey spiritual messages. As a representative art form, passura are significant on two levels: to the local community, they convey visual messages from within, while to viewers from outside the community, the icons’ uniformity of arrangement strongly implies an expression of cultural identity. However, knowledge concerning passura design is passed down tacitly from generation to generation, and few outside the community actually understand the underlying meaning of the passura, leaving them able to appreciate only their aesthetic aspects. This study focuses on developing an understanding of the logic of the imagery in the passura in order to investigate the method by which meaning is embedded in them through certain design strategies.

Keywords: passura; Toraja; shape grammar; ornament; ethnocomputation

1. Introduction
The region of Toraja in South Sulawesi, Indonesia, is well known for its iconic architecture, emblematic patterns and ritual ceremony, where physical and symbolic language are seamlessly interwoven. The significance of its traditional house, tongkonan, is not defined simply by its physical function as a shelter, but by its cultural role as a sacred monument symbolizing family identity, including the owner's legacy and social status. The tongkonan's distinctive roof signifies the genius loci of the Toraja region. Nevertheless, while the tongkonan's form plays a major part in defining their rural skylines and providing shelter to their people, it is the ornamental engravings on its surface—the passura—that give a voice to their encoded cultural messages, and comprehensively express the Torajan style (Adams, 2006; Kis-Jovak, 1988; Waterson, 2010, 1988). Passura designs are inspired by local folklore, as well as animals, plants, tools, and other natural or artificial objects that are significant to the Torajan people. There are about 70 design types that remain widely used in rituals, crafts, and traditional architecture (Kadang, 1960; Pakan, 1961; Sande, 1989). Although passura can be considered pictograms or ideograms, the pictorial messages in passura are not always as obvious as in other glyphs; the shapes are not designed to be read phonetically like letters or words, as in the case of Chinese characters or hieroglyphs, or as numbers, as in some Mayan glyphs (Coe and Stone, 2005). The relationship between a shape and its description may be one-to-many, many-to-one, or one-to-one, and it is this subtlety that makes passura unique.

In passura designs, subjects and meanings can be expressed as two types: abstract ornaments, where the actual subject is not directly recognisable, or figurative ornaments, which directly depict their subject (See Fig.1.). While the figurative patterns hold equally important messages to the abstract ones, their symbolisation process is more straightforward, as they portray actual subjects. The subjects, which include roosters, dogs, pigs and buffalo, mostly portrayed from the side, can be immediately recognized, and linked to associated values and meaning in context. However, in the case of abstract ornaments, depiction of the subject is not straightforward. The symbols A3, A5, B2, B6, C1 and C3 in Fig.1. look similar to one another, yet they convey different meanings. For instance, B6 (Paqtedong Tumuru) depicts a buffalo sitting in the water (symbolizing a wish to own more buffalo), and A5 (Paqbarana') represents the endpoint of a banyan leaf (symbolizing a wish for fortune). It is this subtle abstraction that marks the Toraja's idiosyncratic style. The tendency to utilise a specific style of abstraction over direct portrayal of a subject may be observed widely in passura designs, and is indicated
Whereas most of the previous studies have highlighted passura's significance through an anthropological lens, the transformation process of how an actual object is converted into a pattern and then how the pattern is applied to architecture is seldom explored. For instance, documentation on how the order of symmetry governs the style and how the symbolic message is expressed in architecture is limited, as this knowledge is passed tacitly from generation to generation within a master-disciple relationship.

In addition to relying on implicit knowledge to sustain this legacy, this study aims to investigate and interpret passura's design principles into explicit documentation based on the following premises: first, that the consistent style indicates a systematic set of design rules governing the translation of the natural object or local cultural artifact into the Passura design style; and second, that passura's role as an indigenous visual language suggests an order for how messages are articulated. The former focuses on how the engraver represents the surrounding environment. The latter concerns the passura's role as a communication device via architecture.

2. Methods

This research investigates the above premises using both a top-down and a bottom-up approach. "Top down" means studying a cultural artifact through the lens of an existing theoretical framework, which may or may not represent the actual knowledge (e.g., fractal geometry in nature or cultural shapes). "Bottom up" follows from Grounded Theory (Glaser and Strauss, 1967), which focuses on developing a theory from field data. The top-down approach best fits situations where the maker/designer no longer exists, leaving no access to the authors or keepers of the knowledge (e.g., excavation/archaeological). For our subject, the bottom-up approach is conceivable, as the passura engraving practice remains active among the Torajan, and both the maker and the production technique are accessible. Yet, this does not necessarily mean direct access to the design knowledge is available, as the technique is transferred tacitly. Therefore, this research will use the ethnocomputation method (Muslimin, 2014) by integrating a computational design analysis of passura patterns, which will serve as design evidence, and observation of the engraving process in the field.

The study location, Kete Kesu, is a village in Toraja of about 20 families. This village is chosen for its wide range of passura applications on houses, barns and coffins (while some other villages in Toraja are famous either for their tongkonan, or burial sites, in Kete Kesu, one can find both of them in one place to assess the passura design language in different embodiments). Data from this location were collected through observation, interviews and surveys (Fig.2.). First, in our observation, we asked local engravers to draw passura on paper, to capture the procedure they use. We found that most engravers draw a grid first, to use as a guide, before drawing the motif. There was only one engraver, who possessed superior drawing skills, who drew the motif directly without the use of a grid; however, the output was not as consistent as the others'. The use of a grid permits the motif to be multiplied across a larger surface more easily. This grid system will be further discussed in the latter part of this section.

Second, during our interview with the lead engraver, we asked for specific information regarding the passura design process: from order to delivery. Our source stated that the engraver will first learn the background of the owner, such as his/her gender, achievement and legacy in the past, as well as the community's general perception of the owner. The engraver will then interpret this information and decide which passura motifs will fit the owner's characteristics (e.g., intellectuality, leadership, or religiosity) and wishes (e.g., wealthy descendants, prosperity, etc.). The motifs are then arranged proportionally to the person's character. Findings regarding the proportion system from this interview will be discussed in section 4.

Third, in surveying the application of the passura on houses, barns and coffins, we also inspected the actual objects that were being used as models for the design (e.g., plants, animals and built artifacts). We found that
most of these objects are found within 500 meters of the village. This proximity shows a close relationship between the surrounding environment and cultural representation among the Toraja. Direct exposure to the role of the object in nature or culture (e.g., how the fern grows, how the buffalo lives, and how an artifact is used in a ritual ceremony) contributes to how the object is represented. This influence from nature will be discussed later in section 3.

The data are analyzed with the Shape Grammar method (Stiny and Gips, 1971) to interpret the transformation and visual association processes of passura designs. Stiny’s pioneering computational design study of a traditional Chinese lattice window design — the Ice-Ray Grammar (Stiny, 1977) — provides deeper insight into not only how a particular design can be regenerated, but also how the logic behind it may be applied to other aspects of the design, such as its structure and fabrication method. Stiny achieved this by representing the design process according to a set of shape rules, from which a rule computation generates similar designs based on the same style. In contrasting the subtlety of passura, the Shape Grammar method highlights the number of design deviations during the association process in three phases. Firstly, a passura grid is defined as a basis for the visual structure; secondly, the underlying logic of the passura subject abstraction process is interpreted; and thirdly, abstracted geometry is superimposed on the grid system to reconstruct the passura designs.

3. Passura Design Grammar

Based on our observations of the engraving process, a crossed rectilinear grid (the kite module, ) was employed to define the basic structure of an ornament. The symmetrical properties of this module provide an initial hint into the subtle differences in passura engravings (Fig.3.). The kite module has eight orders of symmetry, allowing for eight ways of transforming the kite back into its original shape, using four rotation angles and four reflection planes. Accordingly, an object contained in a single module has eight variations, and therefore eight designs (Knight, 1995). Furthermore, if two modules are combined using shape grammar rules, , the number of variations increases to sixteen (eight orders of symmetry multiplied by two modules). The grid’s symmetrical construction enables the modules to be generated in various combinations, indicating that the grid does not simply serve as a set of guidelines for Torajan engravers, but as a versatile tool for design ideation, and as a pedagogical device to educate future generations.

Secondly, types of motif geometry for each module and their underlying abstraction schema are identified. At first glance, the range of abstract patterns can be distinguished as curved and straight lines. However, considering the close proximity of the actual object to the village, where Torajan artists may interpret and express the subject’s behaviour in addition to the form, these patterns could be derived from the same parametric schema (Fig.4.). One ubiquitous natural design subject, a fern stem, may be portrayed blossoming into different forms that provide both static and dynamic symbols of nature. A schema by which a simple curve may extend into a circle or complex spiral can then be inferred by examining its earlier and later stages in nature. Through forming a schema based on this inference, objects can be aligned according to a grid more systematically, either by modulating a certain variable (e.g., the number of spiral rotations with rule, ) or by substituting curves for lines. For instance, as can be seen in Table A-Fig.4., a section of a snail shell is an enlargement of a spiral, while a wooden hook is a simplified spiral in straight lines. Further abstraction can be achieved by applying an additive rule, for example by revolving and multiplying a stem or a hook around the centre point to generate more complex shapes, as shown in Table B.

Fig.3. Passura Grid and its Rule of Symmetry

Fig.4. Passura Abstraction Schema

Thirdly, to further investigate the logic underlying the visual associations between the actual object and the pattern, rules from the grid and abstraction schemas are combined to generate compositions that may resemble passura designs. To illustrate this, the modular grid serves as a container, with a shape from Fig.4. filling it and representing its contents. As the container is computed...
using Shape Grammar additive rules, a number of designs that simulate passura designs are generated using three types of spatial transformation: rotation, reflection and translation (Fig.5). More specifically, we let eight additive rules \( R_1 \rightarrow R_8 \) (R1 to R8 in Fig.5.) generate compositions based on different values, such as rotation angle in the following incremental order: \( 0^\circ, 90^\circ, 180^\circ \) and \( 270^\circ \). Combined methods, such as rotation with reflection and/or translation, are also applied to determine to what extent the results resemble passura designs. The computation works in multiple iterations. In the first iteration, it simply involves multiplying the basic shape into different combinations. Subsequent stages are recursive, using the results from their preceding iteration as the initial patterns for multiplication into further compositions.

The resulting compositions shed light on the subtlety in passura, as they appear with only slight variation according to a different rule and iteration. Some results directly resemble passura patterns in the first iteration, namely designs A, B and C, while others require further iterations, where two modules are combined and transformed together, such as designs J and K. Other compositions generated in the second iteration serve as a secondary grid to represent the actual subjects. This was achieved by connecting parts of shapes with curves or lines to create alternative trajectories for curves from designated starting points, as seen in design M, N, O and P, in Fig.3.

This rule aligns with symmetrical objects found in passura designs (e.g., buffalo, water-striders). When an asymmetrical object has substantial meaning, a passura transformation rule will align it proportionally to the design language. In other cases, the manner in which an object is situated in nature or cultural events enhances its symmetrical appearance. This can be seen in design M, which represents part of a bathing buffalo's head submerged underwater, with its reflection projected symmetrically on the water. In another example, in which a buffalo is lying on the ground during a funeral ceremony, with legs tensed and pointing in different directions, the design aligns with a cross-square in the grid (Pagtedong).

The design is multiplied across a larger area by recursively propagating the steps above. The portrayal of objects becomes clearer in accordance with the repetition of the patterns on larger scales or longer planes, and is enhanced by the contrast between the dark and light areas. Considering the subtlety of these designs, to recognize the passura's subjects, viewers need to alternate their focus between contrasting elements such as figures and the ground, or lines and planes.

4. Passura Application in Architecture

The focus of this discussion shall now move to an architectural application, where passura designs are embodied in the built environment. Passura design elements are applied directly to a house and barn during the post-construction stage to express the particular character or messages of the building's owner. Based on our interview with the lead engraver, passura artists communicate this by modulating the area ratio of one pattern relative to another, within a certain proportion. A knowledgeable observer may then be able to discern individual characteristics of the owner, or other embedded messages, by mapping the meaning of each pattern, and how it is proportioned relative to neighbouring patterns (Waterson, 1988). The subdivision diagram of a rice barn facade in Fig.6. interprets the schema by which passura design is applied.

Using the grid system discussed earlier, passura designs are applied either as a single motif or as a continuous pattern in a linear or planar manner to form the ornamental reliefs engraved into the wall and exterior side ceiling panels, and some decorated structural elements of the house and barn. They convey their primary message on the sections at the front of the house, and occasionally on a hidden, yet important part of the structure, such as its foundational posts. While some passura elements are aligned with the structural module of a building, in some cases artists consider its façade to be a blank canvas, which thereby overrides the method of applying passura proportionately to structural modules. In other words, there may be no
correlation between structural composition (e.g., which part supports the heaviest load) and the meaning of the ornament. To exemplify how these proportions are distributed, the main facade is separated into two parts for analysis: the front gable and the wall panel (Fig.6).

The front gable composition is symmetrical. Based on a roof truss system, comprised of a middle plank, triangular frame planks and a base plank, the gable provides the basic layout for a passura design application. This primary layout is generally expressed with two mirroring right triangles that define the gable perimeters, and a base subdivided into rectilinear modules. Its symmetrical construction is further stabilized by mirroring left and right patterns, for a semantically balanced expression of the owner's characteristics. The ratio between the height and the base distinguishes certain aspects of these characteristics. In most cases, the triangle is either proportioned to a greater extent than the base to emphasise a specific characteristic within it, or to a smaller extent to place significance on the embedded meaning on the base patterns. In other cases, instead of a triangular composition, configurations of rotated squares are selected to signify different types of appreciation to the owner (see two images in the second rows in Fig.7.) (Tingting, 2015).

The wall composition is divided into two-by-three square modules, with a wide horizontal band dividing the upper and lower modules. With the exception of the entry door on the left, the wall pattern is vertically balanced with bilateral symmetry. Similar to the gable, the horizontal ratio between the first and second rows can vary. The upper row may be smaller than the lower one to represent a different story, while the horizontal divider between them may be enlarged to function as a row in itself, in which case this row may be subdivided into smaller horizontal segments with linear arrangements.

Within this composition, we measure the ratios used to compose the message and map the semantic meaning from the literature. Fig.7. shows the subdivision values between the roof gable's base and height, mainly found within a 0.8 ratio, in favour of the top area, which is mostly covered with popular motifs (i.e., rooster or paqmanuk londong, and sun symbols or locally known as paqbarreallo). The motif expresses the wishes or appreciation to the owner as someone who consistently practices the norm based on religious principles. However, the motifs for the base area appear more varied; for example, on one gable, the base motif may symbolize wishes for peaceful offspring with an array of tadpole motifs (the paqbulittong siteba’ icon), while on the other gables, the base addresses a message about prosperity with the banyan-leaf motif (paqbarana...
icon) or the importance of having a strong family bond with the seaweed motif (paqtange-lumuq icon). (See Kadang, 1960; Pakan, 1961; Sande, 1989 for a more symbolic description about the icons)

5. Conclusion

This study has examined the underlying concept of passura design, its logical basis and its representation mechanisms. Results from the generative analysis provide an insight into interpreting the artist's visual matching process between the natural or cultural objects embedded within the passura design. The dominance of stylistic abstraction over accurate portrayal is indicated by logical procedures in translating actual objects into the ornamental language; hence, a design schema adheres to the rule of symmetry. The experiment also shows that this rule is applied in multiple stages, ranging from observing the signs of symmetry in nature to aligning and representing the object in the passura design.

Consistent proportion in the architectural applications suggests the use of a systematic schema to address a person's character traits and ritual messages. This schema serves as a unique device for visually interpreting personality traits apart from their physical qualities, something commonly found in the anthropometric systems of Southeast Asian architecture, for example, the use of arms or feet as a unit of measurement for traditional Balinese houses. In addition to the macro-cosmos/micro-cosmos representation in Torajan settlements, such as house form and orientation (Tangdilintin, 1985), the engraved passura provide windows to a more profound cultural dimension that establishes a visual bond between the owner's story and the observer. The practice of composing a visual message highlights the significant role of engravers and passura, as they define the lens by which outsiders interpret the collective history as depicted in the pattern in the built environment.

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