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# Implementing Fractal to Define Balinese Traditional Architectural Facade Beauty: The Kori Agung

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## Abstract

Fractals have been theoretically used to explain visual beauty from the urban scale to the context of architectural facades. How we perceive the visual beauty of architecture is likely dependent on subjectivity. However, the fractal is applicable for defining visual beauty and as a quantifiable method that provides objectivity for analysis. Previous research has used fractals, particularly in facades, to determine the beauty in complex geometry and quantify the complexity. However, the application of fractals in traditional architecture remains to be explored. Therefore, this article will discuss in detail how fractal is a suitable method to study the visual beauty of traditional architectural facades using fractal geometry and fractal dimension index. The case used to illustrate the implementation is Kori Agung of Balinese traditional architecture, known for its grandeur and luxurious facade images. It embodies the visual beauty of its facade due to its textured, layered, and complex visual appearance.



## INTRODUCTION

Analyzing the beauty of architecture is still a topic of discussion by scholars today. The beauty in architecture has been confronted with the duality of subjectivity and objectivity (Grütter, 2020). Despite the subjectivity in looking at the visual beauty of an architectural object, a universal parameter of beauty in architecture helps to set a common ground for describing what composes the beauty and how to define it (Barelkowski, 2018). Currently, fractals have been used to theoretically explain the beauty in architectural visuals, from the context of urban scale to the context of architectural facades (Aykal, Erbas Özil and Hizar, 2020; Ma, Zhang and Lu, 2020; Lavdas and Salingaros, 2022; Katona, 2023; Lee and Ostwald, 2023a; Okuyucu and Baştaş, 2023).

Shape language or shape grammar generally has been used in analyzing and designing architectural shapes and forms. Fractal, the term for a self-similar object that could generate infinitely and often chaotic but still recognizable in order (Mandelbrot, 1977), considers a shape grammar to analyze and explore geometrical rules in the early stage of architectural design (Bovill, 1996; Lorenz, 2009; Sedrez and Pereira, 2012; Ostwald and Vaughan, 2016; Lorenz, Andres and Franck, 2017; Lorenz and Kulcke, 2021). However, in the case of ancient architecture, where the term fractal is unknown, complex geometries in Gothic Cathedrals to Hindu Temples present fractals unconsciously (Trivedi, 1989; Sala, 2003, 2006; Md Rian *et al.*, 2007; Salingaros, 2019). Therefore, not only is the fractal concept applicable in generating fractal architecture, but it also defines geometrical rules of some complexity developed intentionally or not in architecture. In the case of Kori Agung, the formal compositions and the ornamentation have their own rules forming its complex visual so that the visual complexity of Kori Agung is explicable beyond simple geometry.

The appreciation of architectural facade visual beauty, specifically in the context of traditional architecture, is intriguingly still explorable. The Kori Agung aesthetic derives from its ornate and complex architectural form (Suadnyana et al., 2021); hence, it depicts architectural façade visual beauty from its complexity and the fractal nature attached to its facade. Therefore, fractal would be a proper tool in determining the beauty of Kori Agung, thus providing a new perspective in looking at the quality of Kori Agung's visual beauty. This paper attempted to elaborate on how the fractal applies systematically to define the visual beauty of Kori Agung as a traditional building with a particular cultural rule forming its façade. The outcome depicts the fractal nature embedded in its geometry and points out its complexity by the fractal dimensions. The result and discussion of this paper hope to contribute to the knowledge of Balinese Traditional Architecture, specifically in its aesthetic theory.

## FRACTAL IN DEFINING BEAUTY IN ARCHITECTURE

The notion of beauty in architecture has been and still is reflected in two approaches: the first is based on the observer's perception, hence the subjectivity in looking at the object's beauty; in contrast, the second is based on the object, therefore the perceptions dependent to the observed object (Grütter, 2020). This later approach is set to look at the beauty of architecture based on specific rules, whether qualitatively or quantitatively. And these rules are what define the observer's perception of beauty.

The characteristics of objects resemble fractals are irregular and self-similar, often have infinite complexity when iterated, have a non-integer fractal dimension, and are familiar in the natural world (Sedrez and Pereira, 2012; Lorenz, Andres and Franck, 2017; Le, 2021). Two concepts underlying the understanding of fractals in architecture are the fractal geometry and the fractal dimension. While the former concerning shapes lay out a cascade of sometimes infinite, self-similar, meandering, or curving detail as one observes them more closely, the latter measures the degree of the meandering or curving of the texture (Lorenz, Andres and Franck, 2017; Lorenz and Kulcke, 2021).

From the above explanation, the fractal accounts for a fractal-like architectural object's geometrical and dimension rule. Thus, the fractal is related to visual beauty for its ability as a method to point out both the quality in the geometrical form and the quantifiable indicator of the complexity of architectural form as an object expressing beauty, in this case, a facade (Vaughan and Ostwald, 2017; Lorenz and Kulcke, 2021; Katona, 2023; Lee and Ostwald, 2023b, 2023a).

### Fractal Geometry

A fractal shape in architecture is an irregular recursive shape with a self-similarity trait. Furthermore, the following are the characteristics identifying fractal geometry in architecture (Bovill, 1996; Sedrez and Pereira, 2012; Lorenz, Andres and Franck, 2017; Lorenz and Kulcke, 2021):

1. *Self-similarity,* as the essential trait of fractals, is related to symmetry, an important rule of an aesthetic shape creating rhythm and harmony in architecture (Bovill, 1996; Lorenz, Andres and Franck, 2017). The simple concept of symmetry is the bilateral nature, which mirrors compositions from one side to the other. However, considering the complex diversity of geometries in the natural world, no objects in nature have the same size or identical shapes. The cantor-set in Figure 1 exemplifies a self-similarity pattern with the *basic fractal* (explained in point 3) of a singular line. However, the basic fractal does not necessarily have to be a line. Therefore, self-similarity in fractals explains this complex diversity in its recursive pattern.

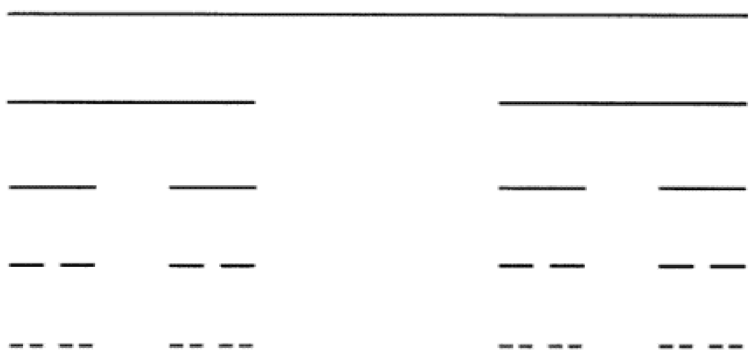


**Fig. 1.** The self-similarity pattern of cantor-set **(Source**: Bovill, 1996).

The fractal geometry adds quality to architecture's visual beauty, shown by the self-similarity traits. According to the quality level of self-similarity, fractals are classified as Exact self-similarity, Quasi-similarity, or Statistical self-similarity (Le, 2021). The first classification appears to have identical shapes as copies of the whole form at different scales. The second contains a few copies of the entire form that might be distorted or degenerated in size and shape; hence, it is only approximately similar at different scales. The last one does not necessarily have copies of the whole but has consistent statistical measures.

2. *Basic fractal (initiator-generator),* the base part that is a similar form of the whole, encompasses the terms initiator and generator of fractal in the repeating process of this base part to create a fractal (Le, 2021). The initiator is the base part itself; it could be in a singular line like the Cantor set in Figure 1 or in Euclidean geometry, like a triangle in a Sierpinski gasket in Figure 2B. For illustration, in the Sierpinski gasket, the initiator as the triangle in the first row on the left corner. Then the collection of scaled copies of the initiator is called a generator. Figure 2B shows the first row in the middle; this generator becomes an initiator if it continues to be scaled and then copies; hence the initiator-generator process continues on and on.

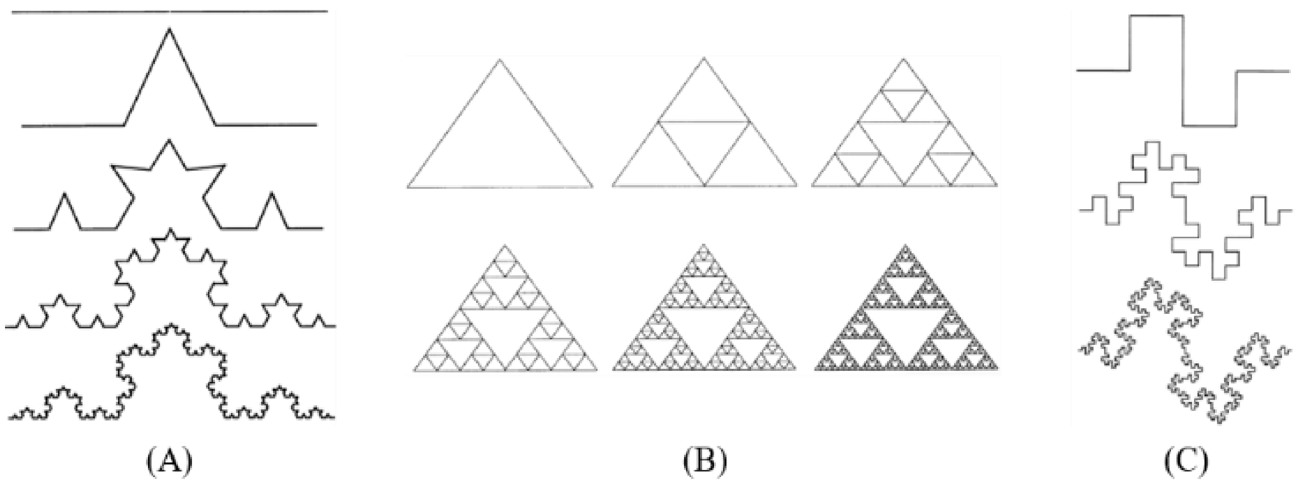



**Fig. 2.** Known basic fractals: (A) Koch curve, (B) Sierpinski gasket, (C) Minkowski curve (Source: Bovill, 1996).

Fractal geometry, specifically in architecture, can be generated intentionally and unintentionally. Thus the classification of fractal based on its genesis encompasses the mathematical or artificial fractal and the natural fractal (Trivedi, 1989; Sala, 2003, 2006; Belma and Sonay, 2016; Ostwald and Vaughan, 2016). The first refers to fractals previously mentioned 'exact self-similarity' nature, which has specifically measured shaping rules. In contrast, the natural fractal relates to the 'quasi self-similarity.'

3. *Space-filling* is a characteristic of fractal geometry that represents the beginning of a pattern that fills a plane. This space-filling material appears as the texture of a surface or a plane, contributing to a surface roughness or visual complexity that fractal dimensions can measure. As illustrations, the Koch, Minkowski, and Peano curves (Figures 2A, 2C and 3) sequentially represent examples of range from a beginning to filling a plane to filling the plane.

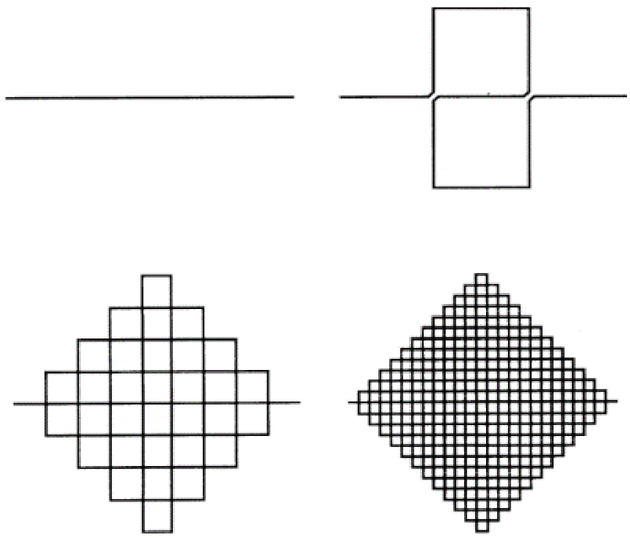


**Fig. 3.** The space-filling curve of the Peano curve (Source: Bovill, 1996).

Space-filling, specifically in the context of Hindu Architecture, according to Trivedi, 1989, appears on the detailed geometry and elements on the outer surface of the Indian Temple. It has sculptures and carvings that represent gods, humans, animals, mythological creatures, leaves, and other decorative elements packed tightly together on the outside of the temple to give rise to a distinctive visual and textural expression on the surface of the temple. The ornament also has repetitions of the shape and specific layering arrangements identified as fractal.

## Fractal Dimension

The fractal dimension provides value in justifying the 'roughness' of fractal geometry. The term 'roughness' refers to the determination of the amount and distribution of the geometry spreads over many scales in a form (Ostwald and Vaughan, 2016); or, in architectural terms, the visual complexity of building surfaces, including building facades. The fractal dimension also applies when comparing building elevation complexity and the surrounding nature (Vaughan and Ostwald, 2011, 2017) and also represents complexity in urban maps (Ma, Zhang and Lu, 2020).

Visual aesthetics in architecture involves the complexity of the form. The fractal dimension can arguably describe architectural aesthetics, including the façade's visual complexity—regardless, implementing fractal dimensions must consider clear parameters for the index to be meaningful (Lorenz, Andres and Franck, 2017). Incorporating fractal dimension in architectural aesthetic analysis brings a new perspective in explaining what parts or elements of an architecture most influence its visual attraction. Further, it compares the complexity among architectural styles or even architectural elevations with its landscape (Lee and Ostwald, 2023a, 2023b).

## FRACTAL IN THE CASE OF KORI AGUNG FAÇADE VISUAL BEAUTY

The noticeable trait of Kori Agung visual is the symmetry of its whole form, a manifestation of balance and unity as the aesthetic principles in Balinese Traditional Architecture (Davies, 2007). The principles of balance and unity in Kori Agung align with the concept of visual complexity in architecture (Barelkowski, 2018; Grütter, 2020). Its façade visual trait derives from the composition of a variety order of formal masses and ornaments. This complexity indicates Kori Agung as a fractal-like object formed by various orders united by a particular pattern (Trivedi, 1989; Md Rian *et al.*, 2007; Singh *et al.*, 2022). Therefore, Kori Agung is an appropriate architectural case analyzed with fractal.

Visually, Kori Agung is a solid-mass building with towering multilevel shapes representing a mountain, an essential element of Balinese Hindu society's concepts of the universe (Wiriantari and Semarajaya, 2018; Hardy and Jerobisonif, 2020; Wirawibawa, Putra and Dwijendra, 2021). However, Kori Agung's complex shapes are the visual beauty trait encompassed in layered and textured façade. As previously mentioned, the *Tri Angga* concept is the rule that arranges the Kori Agung formal composition, which consists of the head or top of the body called *utama angga*, the middle part of the body called *madya angga*, and the lower body part or *nista angga* (Wiriantari and Semarajaya, 2018; Subrata and Iskandar, 2021; Subrata and Kasmana, 2022). In addition, more detailed features define the facade (Figure 4): stacked blocks at the top called *tumpang*, a forehead or *gidat*, torso or *pengawak*, armpits or *sipah*, earlobes or *kuping*, and arms or *lelengen* (Saraswati, 2002).

Another notable trait of Kori Agung visuals is the adorning ornaments. Every Kori Agung in the Puri or Pura has a characteristic shape and ornamentation that varies in each region in Bali, and this is also due to the surrounding artist's sculpture characteristics. Ultimately, the mass form, the rules of form composition, and the placement of these ornaments form the visual complexity of Kori Agung. Ornaments decorate each Kori Agung feature according to natural ethics in a hierarchy; for instance, the *gidat* area, which is a top body part, has flying fauna such as birds (*Karang Goak*) and elephants (*Gegajah*), given their great body, put in the lower part represents a strong foundation (Paramadhyaksa, 2009; Suryada, 2011; Prijotomo, Siwalatri and Setijanti, 2012; Sumadiyasa, Budhi Utama and Yudabakti, 2020; Subrata and Kasmana, 2022). Due to the sculptures and carvings, these ornaments have different expressions on each Kori Agung in regions across Bali.

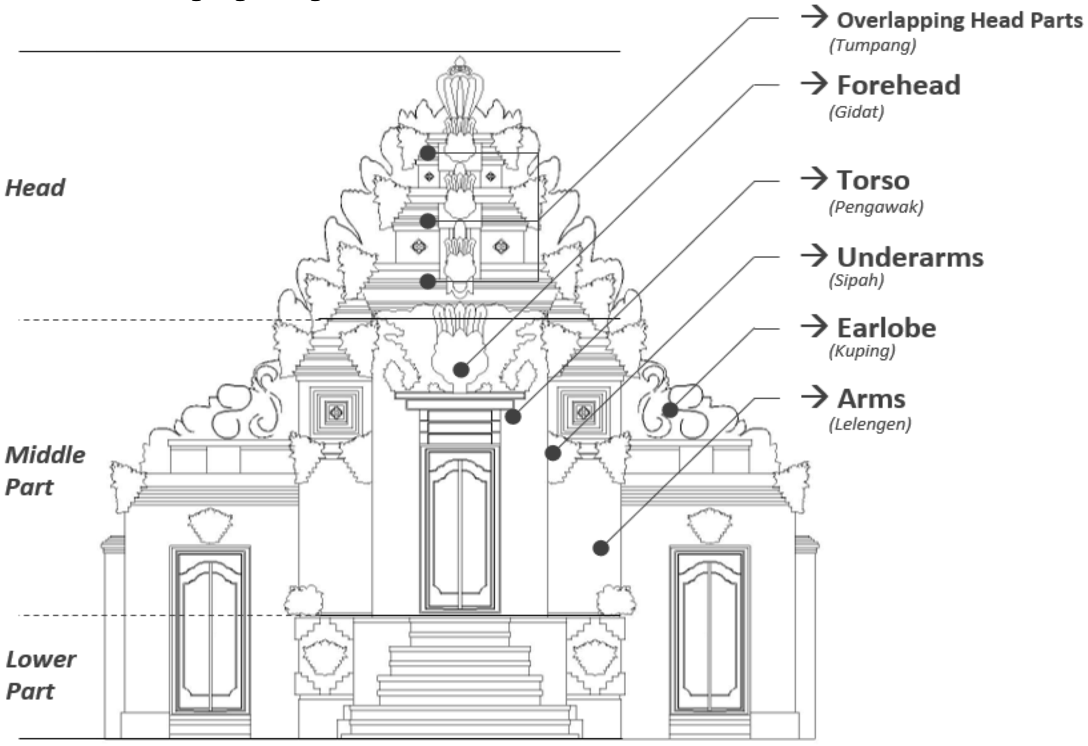



**Fig. 4.** Analogy of human body parts in Kori Agung in Balinese Traditional Architecture (Source: adapted from Saraswati, 2002; Wiriantari, 2018; Subrata, 2021).

Past studies have covered the visual beauty appreciation of Kori Agung in the realm of its intangible aspects, particularly the philosophical values of Kori Agung (Sumadiyasa, Budhi Utama, and Yudabakti, 2020; Wirawibawa, Putra and Dwijendra, 2021; Subrata and Kasmana, 2022). Studies have also described the variety of Kori Agung's forms and shapes and their attachment to its region's teritorial context and history (Wina *et al.*, 2020; Wirawibawa, Putra, and Aritama, 2022). These studies have discussed that Kori Agung's aesthetic is inseparable from the symbolic meaning of Hinduism in Bali. However, geometrical-wise, the visual complexity essential to Kori Agung's visual beauty has not been systematically discussed.

In understanding the complexity of a building facade, it is necessary to analyze it as a superimposition of architectonic layers (Katona, 2021). It infers that visual-wise, the façade of Kori Agung is a layover of formal mass compositions and ornaments embellishing them. Therefore, to look into the façade, the mass compositions and the ornaments are considered layers, and the expressions of the ornaments considers an added texture to the layers as laid out in Figure 5.

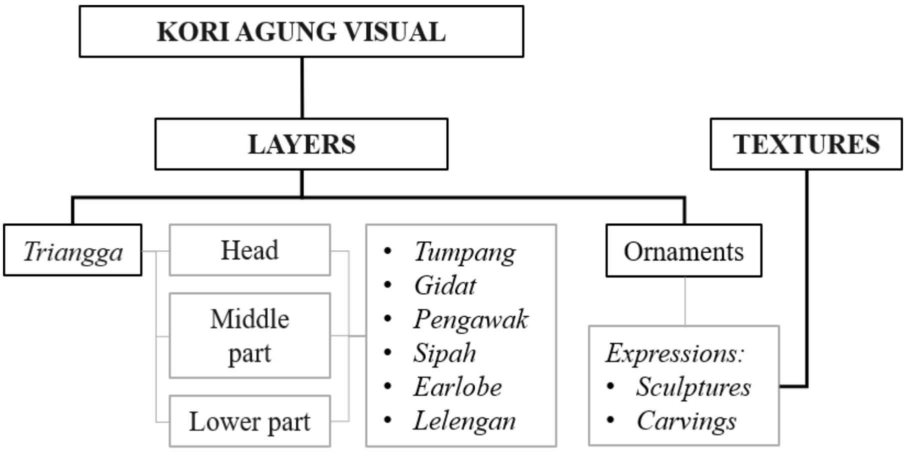



**Fig. 5.** Kori Agung façade visual composition.

## METHODOLOGY

Analyzing visual beauty from the perspective of fractals in architectural form belongs to the analysis of shape language architecture (Trivedi, 1989) or a geometric language that defines a shape and helps the design process (Sedrez and Pereira, 2012). In the case of Kori agung visual beauty, the analysis applies on a small scale, namely determining the fractal component of a building and observing the pattern or order of its repetition. On a large scale, it concerns fractals in urban morphology. However, the analysis discussed in this paper is a small-scale fractal analysis with Kori Agung façade visual beauty as the subject.

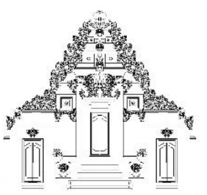
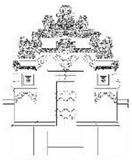
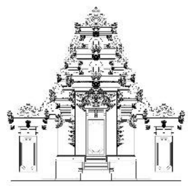
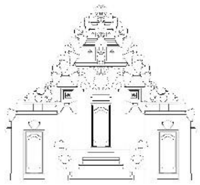
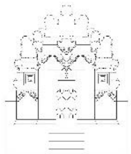
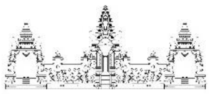
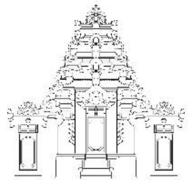
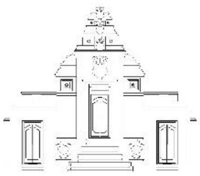
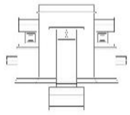
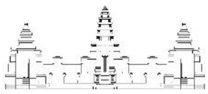
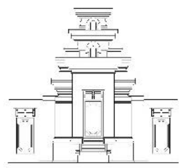
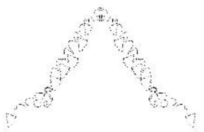
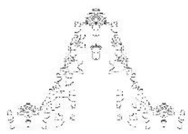
This paper discusses fractal as an analysis method for the beauty of four Kori Agung façades, which are the front elevations, photographed from an angle as perpendicular as possible with the help of a drone and then sketched using AutoCAD, then analyzed the visual complexity using the fractal concept conducted three steps in two stages. The analysis begins with visual observations encompassing two steps: classifying the facade layers and visual observations of fractal geometry. The second stage is justifying the visual observations by calculating the fractal dimensions using the Hausdorff box-counting method.

### Defining Kori Agung Façade Layers

To systematically analyze the Kori Agung façade, it is necessary to dissect the formal configurations. Determining the façade layers conducts the dissection of the Kori Agung façade according to the *Tri Angga* and ornament rules that form the visual compositions. The Kori Agung façade layers then become a reference for the subsequent analysis, which calculates the fractal dimensions.

Visual observations applied to four cases of Kori Agung, three Kori Agung of Puri, and one Kori Agung of Pura, namely, Kori Agung of Puri Agung Gianyar, Puri Agung Kesiman, Puri Agung Denpasar (Pura Satria), and Puri Saren Agung Ubud. The Kori Agung formal trait is a massive gate usually composed of one main gate (body or *pengawak*) and a smaller, profane gate on each side of the main entrance, also classified as the body. However, the main gate's body mostly has the complete components of the human analogy features, as previously explained in Figure 4.

**Table 1.** The Layers of Kori Agung façade

| **Layer** | **Kori Agung Façade Layers** | | | |
|---|---|---|---|---|
| | Kori Agung Puri Gianyar<br>1 | Kori Agung Puri Kesiman<br>2 | Kori Agung Puri Denpasar (Pura Satria)<br>3 | Kori Agung Puri Saren Ubud<br>4 |
| **(A)** Formal mass with ornaments expressions | <br>1A | <br>2A | – | <br>4A |
| **(B)** Formal mass without ornaments expressions | <br>1B | <br>2B | <br>3B | <br>4B |
| **(C)** Formal mass without ornaments expressions and Head parts (*tumpang*) ornaments | <br>1C | <br>2C | <br>3C | <br>4C |
| **(D)** Head parts (*tumpang*) ornaments | <br>1D | <br>2D | <br>3D | <br>4D |

Observation showed that, visually, Kori Agung is composed of several layers. The layers are composed of superimposition of formal mass and ornaments. These layers are characterized based on the visual scales of the façade, from the overall visual layer of formal mass to the detailed layers, which are the ornaments on each formal feature (Katona, 2021). The rules of ornament placements and the mass structure, according to *Tri Angga* rules, organize the visual of the Kori Agung façade. Various ornaments are applied on each Kori Agung component, forming the overall shape of the facade. Thus, the layering of the Kori Agung facade refers to the superimposition of formal mass and ornaments with the ethics of the *Tri Angga* and the ornament placement.

Table 1 shows that four layers characterize Kori Agung's facade. The first layer is the overall visual of Kori Agung, which is the formal mass along with its ornament expressions, meaning the sculptures and carvings. The second layer is the formal mass without the ornaments' expression, by definition of seeing the facade configurations without the sculptures and carvings. The third layer sees the façade visually by the formal mass itself, without the ornament expression and the decoration on the *tumpang* (head part). Lastly, the fourth layer sees the ornament on the *tumpang* itself, as it is the most striking part of the visual of the Kori Agung façade. For context, these layers are sequentially given codes by A, B, C, and D as a reference for the subsequent results and discussion regarding geometric and dimensional analysis. The four cases of Kori Agung are also given codes as case 1, 2, 3, and 4, and for effectiveness, would be referred to as these codes throughout the whole result and discussion.

Of the four cases, the Kori Agung 3 is the only one without the ornament expression (Table 1). As shown in layer A, the other three cases display the sculptures and carvings on their ornaments; hence, these Kori Agung facades' overall visual is textured (Table 1: layer 1A, 2A, 4A). In contrast, layer 3B depicts the overall façade visual of Kori Agung case 3, a formal mass without ornament expression.

## Fractal Geometry Analysis

The fractal geometry analysis aims to define the nature of order and complexity on the surface of an architectural object, such as a facade. Analyzing an architectural façade should consider the components configuring its shape and acknowledge it as a superimposition of layers on particular visual scales, interpreted as approaching a facade from a specific distance to a closer look (Schumacher, 1987; Katona, 2021); hence the fractal geometry is observed according to the determined layers. In observing the visual aesthetic of architecture façade, complexity and diversity of an order are determinant principles (Lee and Ostwald, 2023a). Diversity of order means the quality of an aesthetic form composed of various elements in order without chaos or monotony. Furthermore, complexity depicts the complex interrelation of the various elements in the visual of an architecture.

Analyzing the formal component composing an architecture based on fractal highlighting its visual quality. Acknowledging that fundamentally, the aesthetic concept of Kori Agung embodies the ideas of balance and unity (Davies, 2007); however, due to the layered configurations, the façade indicates a visual complexity.

Therefore, the visual observation of fractal geometry is conducted on the determined layers of the Kori Agung façade, attempting to look for the fractal characteristics in the façade. Self-similar iterations are carried out to discover the repetition of shapes and their growth patterns, if there are any. The basic fractals and space-filling observations were carried out to indicate if there are any known fractals (Figures 2 and 3) in the Kori Agung façade visual.

## Box counting - Hausdorff Dimension Analysis

The visual observations obtained the façade layer classifications and identified the fractal geometry materials in Kori Agung. Furthermore, the next stage is conducting fractal dimension analysis to get a quantifiable index of four Kori Agung cases to justify the visual complexity of the fractals on each layer. In other words, the fractal dimension is necessary to depict the interrelation of various parts configuring the Kori Agung façade.

The fractal dimension analytical method is Box-counting with Housdorff dimension, which belongs to the geometric-mathematical method by Bovill, 1996, in which Ostwald and Vaughan, 2016, later provide a more technical explanation of the steps for calculating fractal dimensions and elaborate on the result display. Nevertheless, both have a basic understanding of fractals which refers to Mandelbrot's idea.

Box-counting Hausdorff dimensions are currently the most reliable and straightforward method to calculate how complex a surface is in architecture, thus resulting in consistent fractal dimensions (Bovill, 1996; Ostwald and Tucker, 2007). In architecture, box-counting applies to analyze the fractal complexity index so that it is possible to compare further the fractal complexity between one typological case study and another (Lorenz, 2009; Vaughan and Ostwald, 2011, 2017). The implementation of box-counting is a layover of a grid on the architectural image, for instance, a façade, then records and counts the boxes filled with lines, for then calculated with the Hausdorff dimension formula as shown in equation 1 (Ostwald and Tucker, 2007; Ostwald and Vaughan, 2016).

As shown in Figure 6, the box-counting commences by placing four sets of grids over each façade layer of Kori Agung. Considering the limitation of the photograph tracing process to produce the Kori Agung sketch, due to distance differences while taking photos of some cases, the drawing does not necessarily precisely represent the Kori Agung actual height and width; however, it relies on the proportions nonetheless. In this case, the number of grid scales is limited to four grids.

The box counts for each layer of Kori Agung are then measured by using the Hausdorff formula in the following equation:

$$D_{(box,\,2\text{-}1)} = \frac{[\log(C2) - \log(C1)]}{[\log(S2) - \log(S1)]} = D_b \text{ Index} \quad (1)$$

**Where**:

*Db* = *box count fractal dimensions index*
*box 1* = *grid box (prior zooming scales)*
*box 2* = *grid box (further zooming scales)*
*C1* = *box count (prior zooming scales)*
*C2* = *box count (further zooming scales)*
*S1* = *grid size (further zooming scales)*
*S2* = *grid size (further zooming scales)*

This Fractal dimension calculation results in an index that depicts the complexity of the façade. However, the index does not encourage a specific ordinal label for beauty categorization. Nevertheless, it allows us to describe and compare architectural cases by the measurable degree of complexity. The fractal dimension index is interpreted as follows: the closer the index value is to 1.00, the simpler the form is; the closer it is to 2.00, the more complex the form is (Bovill, 1996; Ostwald and Vaughan, 2016).

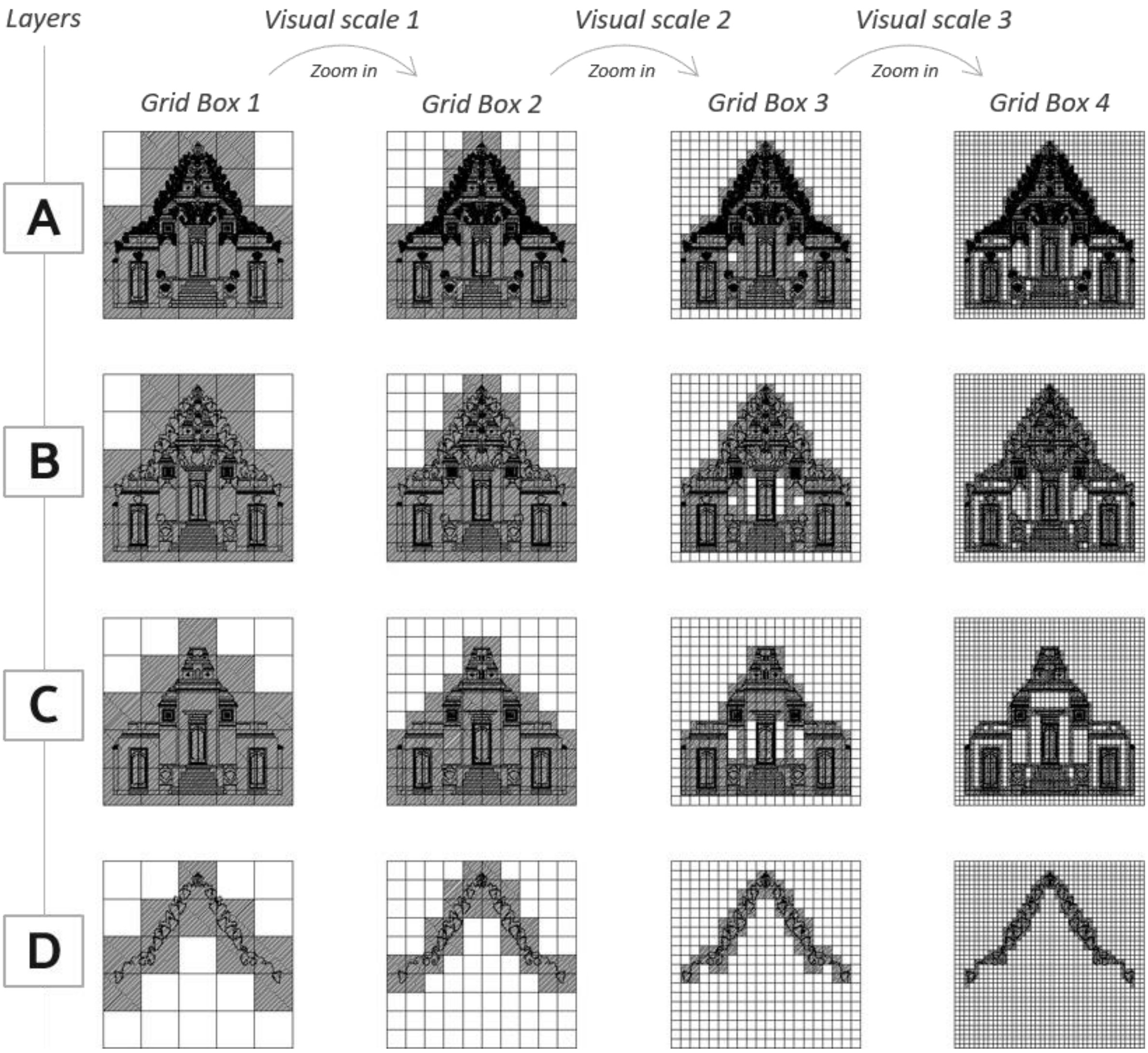



**Fig. 6.** Box counting projection of Kori Agung in each visual scale of layers.

## RESULTS AND DISCUSSION

The results and discussion present three interrelated points regarding the outcome of implementing fractal as a method to analyze Kori Agung visual beauty. The first one discusses the fractal geometry according to the Kori Agung façade layers. The second discusses the fractal dimension as an index to depict Kori Agung façade complexity, and the third is the relation of the two outcomes.

### Fractal Geometry in Kori Agung Façade

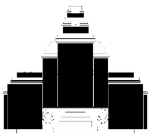
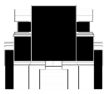
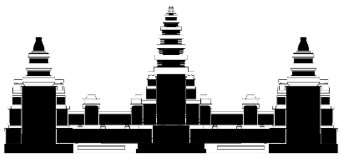
The next step of the visual observation is analyzing the fractal geometry trait of the cases by looking for the fractal characteristics in the façade visuals. The aesthetics of the overall form of the Kori Agung façade is composed of two configurations: the main structure, which is the body (pengawak) of Kori Agung according to *Tri Angga* and all the body features, and then the ornamentations attached to the main form arranged according to the compositional rules in the design ethics of Traditional Balinese Architecture (Gelebet, Puja and Regional Cultural Documentation (Indonesia), 1985). Thus, fractal geometry analysis is carried out according to the layers formed in the facade components, as illustrated in Table 1.

The first trait of a fractal is the self-similarity. Thus, the analysis began to look for self-similarity characteristics in the Kori Agung facade. Self-similarity in the façade of Kori Agung is about the repetitive shapes that appear in the formal mass configuration and the ornaments.

Table 2 shows the Kori Agung façade visual self-similarity characteristics according to the *Tri Angga* rules in layer C of the four Kori Agung cases. It can be seen that self-similarity is visible on the head and middle body in case 1 and case 4. In case 2, self-similarity is visible only in the middle part of the body. However, case 3 has self-similarity to its whole façade, the head, middle body, and lower body parts—the self-similarity for cases 1, 3, and 4 initiated by the *pengawak*, *lelengan*, and *tumpang*; case 2 is self-similar in the *pengawak*.

The shape of the *pengawak* and *lelengan* of the profane and main gate of Kori Agung is similar. In all cases, the *lelengan* is a scaled-down version of the *pengawak* in proportion. The *tumpang* in cases 1, 3, and 4 is self-similar, scaled down proportionally from the base to the top of the *tumpang*.

**Table 2.** The Self-similarity of Kori Agung layer (C)

| **Self-similarity of formal mass shapes in façade visual** | | | |
|---|---|---|---|
| **Kori Agung Layer** | **(C)**: Formal mass without ornaments expressions and Head parts (*tumpang*) ornaments | | |
| | Head | Middle Part (Body) | Lower Part |
| **(1C)** Kori Agung Puri Agung Gianyar | |  | - |
| **(2C)** Kori Agung Puri Agung Kesiman | - |  | - |
| **(3C)** Kori Agung Puri Agung Denpasar (Pura Satria) | |  | |
| **(4C)** Kori Agung Puri Saren Agung Ubud | |  | - |

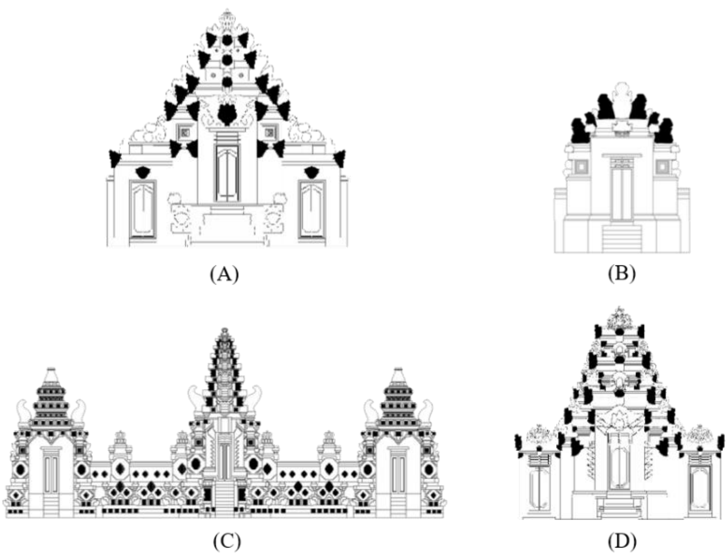


**Fig. 7.** Self-similarity of ornament shapes in Kori Agung façade visuals. (A) *Goak* ornaments on case 1, (B) *Goak* ornament on case 2, (C) *Pepalihan* ornament on case 3, (D) *Goak* ornament on case 4.s

Figure 7 shows that self-similarity is also visible in the Kori Agung ornaments on layer B, the formal mass without ornament expression, so that the ornaments are visible as shapes without the texture. Figures 7A, 7B, and 7D show the self-similar of the head part ornament, *goak*, a representation of a crow in cases 1, 2, and 4. Figure 7C shows the self-similar of the ornament *pepalihan* in case 3.

The self-similar pattern is also found in the *pepalihan tiasan*, the sculpting on the base and top of each Kori Agung features, visible as an array of lines in the meeting between the head, middle body, and lower body parts as seen in Figure 8. The arrangement of these lines refers to one line length on the base of Kori Agung lower body part, which indicates the cantor-set.

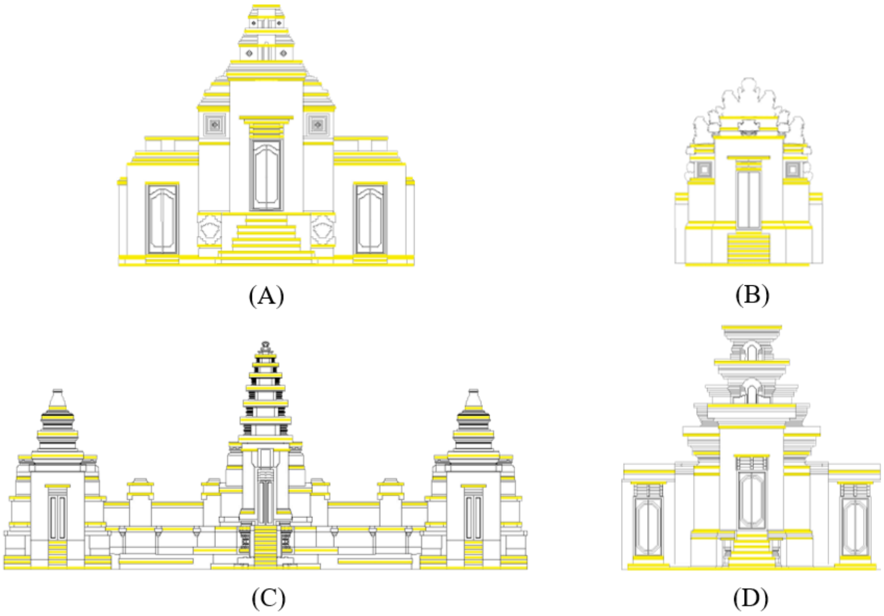



**Fig. 8.** Cantor-set of Pepalihan in Kori Agung façade visuals. (A) *Goak* ornaments on case 1, (B) *Goak* ornament on case 2, (C) *Pepalihan* ornament on case 3, (D) *Goak* ornament on case 4.

Figure 9 shows the appearance of known basic fractals, Koch curve in three Kori Agung cases 1, 3, and 4. The head part ornaments or *tumpang* of the cases resembles the Koch curve found in all layers for cases 1 and 4, on layers B, C, and D for case 3. However, the Koch curve is more visible in layer D, with the *patra punggel* ornament on the head part.

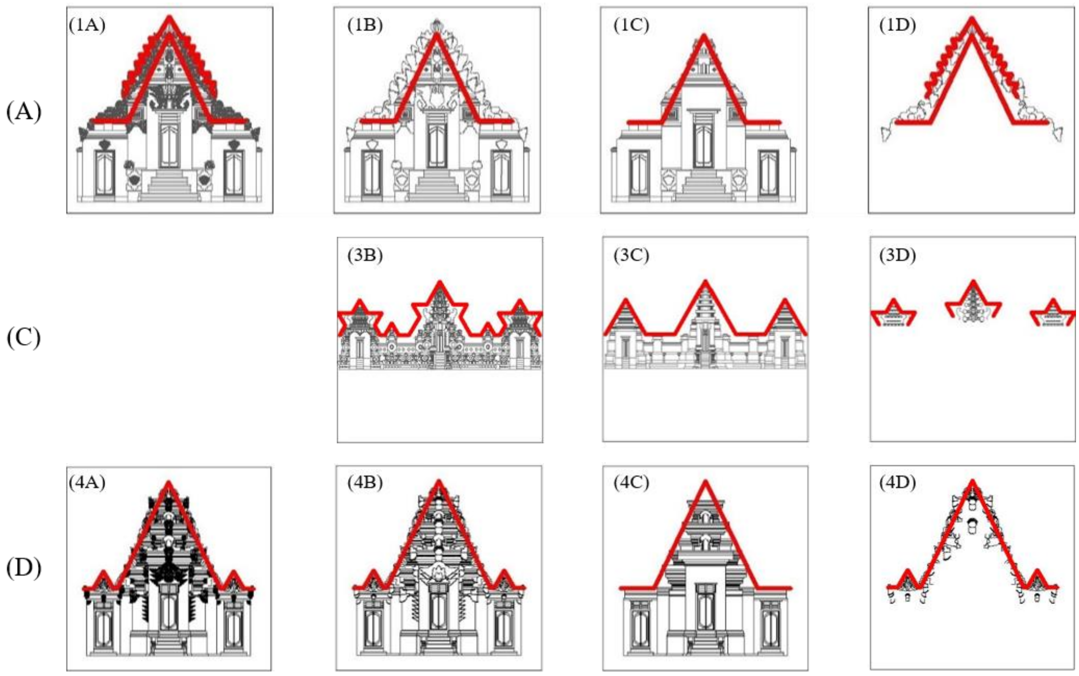



**Fig. 9.** Koch curve-like pattern in head parts ornament visuals on (A) case 1, (C) case 3, (D) case 4.

From the visual observation, the fractal geometry traits are visible when observed parts by part of the Kori Agung visual composition, like when the façade is observed as a whole as layer A, the cantor set is hidden; hence it is visible when the ornamentation took out, as layer C. The Koch curve is more visible when the *patra punggel*, the ornament on the head part added (layers A, B, D) than when it is observed by layer C. Additionally, the textures of Kori Agung, the ornament's carvings, and sculptures fill the shapes of the ornaments and formal mass features of the Kori Agung; hence it is considered a space-filling element of the ornament shapes in cases 1, 2, and 4.

## Fractal Dimension as Kori Agung Visual Complexity Index

While fractal geometry visually shows the repetition of shapes on the mass layer and its ornamentation shapes are identified, their visual complexity from the ornament's expression, the textures, has not been significantly shown. Therefore, the role of fractal indexes is to depict the complexity value quantitatively. The fractal dimension index represents visual complexity from the ornament expression as the textures of the Kori Agung as characterized in layer A. In facilitating fractal dimension analysis, the box-counting with the Hausdorff dimension method applies to obtain a mathematical value of the façade visual complexity represented by lines, indentations, and points that represent textures and building facade shape components in two dimensions (Ostwald and Vaughan, 2016). The box-counting was applied to all layers of four cases of Kori Agung.

**Table 3.** $D_b$ Index value of Case 1 façade layers

| Layers | Kori Agung Puri Agung Gianyar | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Grid Box** | **1** | **2** | **3** | **4** | **Db Index** | | | |
| | **Grid Size (S)** (number of boxes in grid row) | 5 | 10 | 20 | 40 | **Visual Scale 1** D(box2-1) | **Visual Scale 2** D(box3-2) | **Visual Scale 3** D(box4-3) | **Average** |
| (A) | **Box count (C)** | 21 | 72 | 222 | 768 | 1,78 | 1,62 | 1,79 | **1,73** |
| (B) | (number of | 21 | 72 | 218 | 752 | 1,78 | 1,60 | 1,79 | 1,72 |
| (C) | boxes contain | 19 | 62 | 180 | 506 | 1,71 | 1,54 | 1,49 | 1,58 |
| (D) | lines) | 10 | 28 | 66 | 170 | 1,49 | 1,24 | 1,36 | 1,36 |

**Table 4.** $D_b$ Index value of Case 2 façade layers

| Layers | Kori Agung Puri Agung Kesiman | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Grid Box** | **1** | **2** | **3** | **4** | **Db Index** | | | |
| | **Grid Size (S)** (number of boxes in grid row) | 5 | 10 | 20 | 40 | **Visual Scale 1** D(box2-1) | **Visual Scale 2** D(box3-2) | **Visual Scale 3** D(box4-3) | **Average** |
| (A) | **Box count (C)** | 15 | 46 | 142 | 450 | 1,62 | 1,63 | 1,66 | **1,64** |
| (B) | (number of | 15 | 46 | 142 | 424 | 1,62 | 1,63 | 1,58 | 1,61 |
| (C) | boxes contain | 14 | 42 | 116 | 334 | 1,58 | 1,47 | 1,53 | 1,53 |
| (D) | lines) | 8 | 22 | 54 | 148 | 1,46 | 1,30 | 1,45 | 1,40 |

**Table 5.** $D_b$ Index value of Kori Agung Puri Agung Denpasar (Pura Satria) façade layers

| Layers | Kori Agung Puri Agung Denpasar (Pura Satria) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Grid Box** | **1** | **2** | **3** | **4** | **Db Index** | | | |
| | **Grid Size (S)** (number of boxes in grid row) | 5 | 10 | 20 | 40 | **Visual Scale 1** Dbox(2-1) | **Visual Scale 2** Dbox(3-2) | **Visual Scale 3** Dbox(4-3) | **Average** |
| (A) | **Box count (C)** | - | | | | 0,00 | 0,00 | 0,00 | 0,00 |
| (B) | (number of | 13 | 38 | 116 | 412 | 1,55 | 1,61 | 1,83 | **1,66** |
| (C) | boxes contain | 13 | 38 | 110 | 376 | 1,55 | 1,53 | 1,77 | 1,62 |
| (D) | lines) | 6 | 14 | 36 | 96 | 1,22 | 1,36 | 1,42 | 1,33 |

**Table 6.** $D_b$ Index value of Kori Agung Puri Saren Agung Ubud façade layers

| Layers | Kori Agung Puri Saren Agung Ubud | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Grid Box** | **1** | **2** | **3** | **4** | **Db Index** | | | |
| | **Grid Size (S)** (number of boxes in grid row) | 5 | 10 | 20 | 40 | **Visual Scale 1** Dbox(2-1) | **Visual Scale 2** Dbox(3-2) | **Visual Scale 3** Dbox(4-3) | **Average** |
| (A) | **Box count (C)** | 19 | 62 | 202 | 672 | 1,71 | 1,70 | 1,73 | **1,71** |
| (B) | (number of | 19 | 62 | 202 | 672 | 1,71 | 1,70 | 1,73 | 1,71 |
| (C) | boxes contain | 19 | 56 | 176 | 556 | 1,56 | 1,65 | 1,66 | 1,62 |
| (D) | lines) | 12 | 32 | 88 | 222 | 1,42 | 1,46 | 1,33 | 1,40 |

Tables 3, 4, and 5 show the result of the $D_b$ calculation index representing the degree of visual complexity in each Kori Agung façade layer. The results show the development of visual complexity when viewed from each feature on the facade layer. When observed from layer D, the head ornament (*tumpang*) of the Kori Agung, case 2, has the same visual complexity as case 4, apart from its overall value of visual complexity in layer A, being the lowest of the three other cases. It infers that the carvings and sculptures of decoration that constitute the visual texture of Kori Agung affect its visual complexity.

It is inferred from the fractal index displayed in Tables 3, 4, 5, and 6 that, in comparison, the overall visual complexity of Kori Agung cases (Layer A) ranging from most complex to less complex are Case 1, Case 4, Case 3, Case 2. Visual complexity is the trait of visual beauty in architectural façade (Ma, Zhang and Lu, 2020; Lee and Ostwald, 2023b). Therefore, it can be inferred that the visual beauty of Kori Agung can be ordered in the range above.

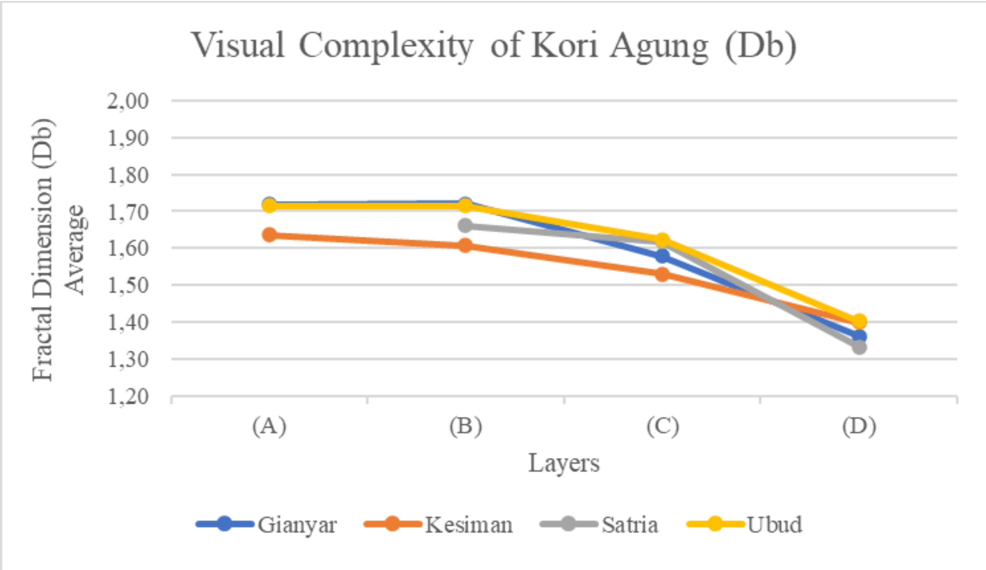



**Fig. 10.** Visual complexity ($D_b$) profile of 4 cases of Kori Agung in each visual scale (Layers)

The chart in Figure 10 shows that the box-counting-Hausdorff dimension calculation result infers the visual complexity of the whole Kori Agung facade in the four cases progresses differently in each Case, led by the non-linear profile of the Db average values of each layer. That means, if we observe layer by layer in each Case, it is found that the Case with the highest fractal dimension index when seen as the overall façade (Layer A), have a lower fractal dimension when seen as just the formal mass (Layer C) or the head part or *tumpang* (Layer D). To explain further, as shown in the chart, the Kori Agung of Puri Agung Gianyar and Puri Saren Agung Ubud have relatively close degrees of visual complexity if seen from the overall visual of formal mass with ornament expression (layer A) and without ornament expression (layer B). However, the result infers, if only seen from the formal mass (layer C) and the head part (*tumpang*) ornaments (layer D), Case 1 has lower complexity than Case 2, despite Case 2 lower overall façade complexity layer A than Case 1.

## Relationship between Fractal Geometry and Dimension in Kori Agung Façade Beauty

Implementing fractal geometry and dimensions in the Kori Agung façade provides insight into breaking down the elements that configure its visual beauty. It defines the embedded nature of fractals within the Kori Agung façade.

Studies have implemented fractal concepts on architectural facades by fragments of its features (Schumacher, 1987; Katona, 2021; Lee and Ostwald, 2023a). While it is effective in theoretically appreciating the visual beauty of an architectural façade, in the case of Kori Agung, the aesthetic principles of unity in Balinese Architecture must be seen as a whole. Kori Agung visual beauty must be seen as a whole from the point of view of the Balinese Architecture aesthetic principles (Davies, 2007); however, it is not by any means that fractal is not included as one of the principles for architectural visual beauty. In fact, the fractal concept encompasses part-to-whole relations in self-similarity, a fundamental trait of fractal (Lorenz, Andres and Franck, 2017). It is, however, not the case in Kori Agung.

The striking bilateral symmetry of four cases of Kori Agung's overall visual forms is evident from mirroring one side of the façade to the other. However, the self-similarity trait would be apparent if the analysis took place fragment by fragment of the Kori Agung features, bringing about the concept of diversity in Kori Agung visual composition elements due to the multiple fractal basic fractals on its façade features (Lee and Ostwald, 2023a). Therefore, according to the fractal concept, the Kori Agung visual aesthetic leads to the quality of 'quasi-self-similarity.' Self-similarity explains that the detail fragment from an object is the depiction of the whole form of the object. A leading study of fractals in Hindu Architecture by Trivedi, 1989, shows the Indian temple displaying this exact trait of part-to-whole relations in its visual, making an excellent example of the term 'exact self-similar' in fractal nature, the highest level of self-similarity traits in fractal geometry (Le, 2021). Nevertheless, implementing the fractal concept brings about the appreciation of Kori Agung visual beauty through each of its visual components with the idea of complexity in the fractal, ensuring the applicability of the fractal concept in most architectural stylistics (Lorenz and Kulcke, 2021; Lee and Ostwald, 2023a, 2023b).

A few studies have incorporated The fractal dimension to compare the complexity of historical architectural cases and interpret the complexity and its history (Aykal, Erbas Özil and Hizar, 2020). The Hausdorff box-counting method also allows even further comparisons of the fractal complexity index of a surface visual between one typological case study and another (Lorenz, 2009; Ostwald and Vaughan, 2016; Lorenz, Andres and Franck, 2017; El-Darwish, 2019; Lorenz and Kulcke, 2021). Reminiscing the layered and textured visual trait of the Kori Agung, implementing the fractal concept to Kori Agung must ensure the characterization of the visible layers, considering there might be some visually hidden fractal traits, especially the geometry.

## CONCLUSION

The fractal concept encompasses geometry and dimension analysis, applicable to visually analyzing most architectural styles, from ancient to contemporary architectural facades. However, implementing fractal to Kori Agung is distinct due to the layers in the façade yield from the *Tri Angga* and its ornament rules that configure its shape, initiating the visual complexity. Additionally, it is clear that Kori Agung's formal configurations are beyond fractal awareness; hence, executing fractal concepts to analyze the facade requires careful iterative visual observations. Significantly, the fractal geometry visual observation. Nevertheless, the fundamental trait of fractals, the self-similarity of the geometries, aligns with Kori Agung's recursive shapes that are prominent in the formal mass and ornaments. Additionally, implementing the fractal concept in Kori Agung helps with defining the quality of its beauty without aiming to classify which form is good or bad among the cases but to give an insight into reading the visual beauty through the fractal quality of Kori Agung in category (Fractal geometry traits showing the harmony and balance in its formal order through self-similarity levels, the dimension showing the degree of complexity inferring the result of variation of order).

The rules of *Tri Angga* generate the nature of quasi-self-similarity in the Kori Agung that appears from the repetitive shapes on its facade. The repetitive pattern and some basic fractals occur proportionally due to the formal mass and ornament configurations, not necessarily on an exact measurement. Although the fractals in Kori Agung do not represent the concept of part-to-whole, the nature of self-similarity still explains the unity of the Kori Agung Visual due to its symmetrical trait; in this case, implementing fractal geometry analysis should be accompanied by the understanding of Balinese Aesthetic principles.

The Fractal dimension ($D_b$) indicates the complexity of the fractal geometrical arrangement on each layer of Kori Agung. The fractal dimension index represents visual complexity from the ornament expression as the textures of the Kori Agung as characterized in layer A. However, setting clear parameters is necessary to obtain a valuable index, such as which lines, curves, or indentations would be counted in the box-counting analysis; hence, the characterization of layers would be helpful.

Looking at the Kori Agung visual according to its façade configurations as a prior guideline to dissect layers of the façade itself and further analyzing in fractal geometry and dimension becomes an intriguing method to explore its notable visual beauty. However, implementing fractal in visual analysis for further research needs the development of technological tools, specifically in the fractal geometry iteration, especially in the context of traditional architecture. As for the fractal dimension, the nature of the fractal dimension provides a complexity index of an architectural façade that is only approximate. However, suppose the components of the architectural façade visual—the Kori Agung layers—are set clearly. In that case, the lines and curves visible are said to be measurable and valuable, indicating the complexity. Nevertheless, this paper argues that the fractal concept is relevant in defining the façade visual beauty of a building with the main structure as the larger scales and decorations elements as the detailed scales; or, in other words, a building with layers on different scales. Ultimately, this paper hopes to be a stepping stone for a future discussion of whether this framework applies to other Balinese or Indonesian Traditional Architecture contexts.

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## REFERENCES


Aykal, D., Erbas Özil, M. and Hizar, M. M. (2020) 'Architectural Analysis Based on Fractal Dimension on Diyarbakir Mosques Architectural Analysis Based on Fractal Dimension on Diyarbakir Mosques', *Online Journal of Art and Design*, ***8***(1), 41–57.

Barelkowski, R. (2018) 'The Beauty of Architectural Complexity', *International Journal of Design & Nature Ecodynamics*, ***13***(3), 250–259. doi: 10.2495/DNE-V13-N3-250-259.

Belma, A. and Sonay, A. (2016) 'Fractals and Fractal Design in Architecture', *13th International Conference "Standardization, Protypes And Quality: A Means Of Balkan Countries' Collaboration"*, ***17***(3(49)), 282–291.

Bovill, C. (1996) *Fractal Geometry in Architecture and Design*. New York: Birkhäuser Basel. doi: 10.1007/978-1-4612-0843-3.

Davies, S. (2007) 'Balinese Aesthetics', *The Journal of Aesthetics and Criticism*, ***65***(1), 21–29. doi: doi.org/10.1111/j.1540-594X.2007.00234.x.

El-Darwish, I. I. (2019) 'Fractal design in streetscape: Rethinking the visual aesthetics of building elevation composition', *Alexandria Engineering Journal*, ***58***(3), 957–966. doi: 10.1016/j.aej.2019.08.010.

Grütter, J. K. (2020) 'Aesthetics and Beauty', in *Basic of Perception in Architecture*. Wiesbaden: Springer Vieweg, 247–268. doi: https://doi.org/10.1007/978-3-658-31156-8_8.

Hardy, I. G. N. W. and Jerobisonif, A. (2020) 'Makna Simbolis Kori Agung Dalam Kehidupan Ritual Masyarakat Hindu di Bali', *Gewang*, ***2***(1), 16–22.

Katona, V. (2021) 'Relief method: The analysis of architectonic façades by fractal geometry', *Buildings*, ***11***(1), 1–15. doi: 10.3390/buildings11010016.

Katona, V. (2023) 'The Hidden Dimension of Façades : Fractal Analysis Reveals Composition Rules in Classical and Renaissance Architecture', *Fractal and Fractional*, 7(257). Available at: https://doi.org/10.3390/fractalfract7030257.

Lavdas, A. A. and Salingaros, N. A. (2022) 'Architectural Beauty: Developing a Measurable and Objective Scale', *Challenges*, ***13***(2), 56. doi: 10.3390/challe13020056.

Le, C. T. P. (2021) 'Fractal geometry and applicability to biological simulation shapes for sustainable architecture design in Vietnam', *Environmental Science and Pollution Research*, ***28***. doi: https://doi.org/10.1007/s11356-020-08417-9.

Lee, J. H. and Ostwald, M. (2023a) 'Complexity and Diversity in Palladian Facades', *Nexus Network Journal*, ***25***(1), 15–21. doi: doi.org/10.1007/s00004-023-00678-4.

Lee, J. H. and Ostwald, M. (2023b) 'The " visual attractiveness " of architectural facades : measuring visual complexity and attractive strength in architecture attractive strength in architecture', *Architectural Science Review*, ***66***(1), 42–52. doi: 10.1080/00038628.2022.2137458.

Lorenz, W. E. (2009) 'Fractal Geometry of Architecture Implementation of the Box-Counting Method in a CAD-Software', *Proceedings of the International Conference on Education and Research in Computer Aided Architectural Design in Europe*, 697–704. doi: 10.52842/conf.ecaade.2009.697.

Lorenz, W. E., Andres, J. and Franck, G. (2017) 'Fractal aesthetics in architecture', *Applied Mathematics and Information Sciences*, ***11***(4), 971–981. doi: 10.18576/amis/110404.

Lorenz, W. E. and Kulcke, M. (2021) 'Multilayered complexity analysis in architectural design: Two measurement methods evaluating self-similarity and complexity', *Fractal and Fractional*, ***5***(4). doi: 10.3390/fractalfract5040244.

Ma, L., Zhang, H. and Lu, M. (2020) 'Building ' s fractal dimension trend and its application in visual complexity map', *Building and Environment*, ***178***(May), 106925. doi: 10.1016/j.buildenv.2020.106925.

Mandelbrot, B. B. (1977) *The Fractal Geometry of Nature*. New York: W. H. Freeman and Company.

Md Rian, I. *et al.* (2007) 'Fractal geometry as the synthesis of Hindu cosmology in Kandariya Mahadev temple, Khajuraho', *Building and Environment*, 42(12), pp. 4093–4107. doi: 10.1016/j.buildenv.2007.01.028.

Okuyucu, Ş. E. and Baştaş, M. S. (2023) 'Analysis based on fractal geometry of traditional housing facades: Afyonkarahisar traditional housing facade examples, Turkey', *Applied Nanoscience (Switzerland)*, ***13***(3), 2489–2505. doi: 10.1007/s13204-021-02226-3.

Ostwald, M. J. and Tucker, C. (2007) 'Reconsidering Bovill's method for determining the fractal geometry of architecture', in *41st Annual Conference of the Architectural Science Association ANZAScA*. Mealbourne, Australia: Deakin University, 182–190.

Ostwald, M. J. and Vaughan, J. (2016) *The Fractal Dimension of Architecture*. Volume 1. Edited by K. Williams. Torino, Italy: Birkhäuser.

Paramadhyaksa, I. N. W. (2009) 'Pemaknaan Ornamen Murdha pada Arsitektur Tradisional Bali', *Info-Teknik*, ***10***(1), 1–9.

Prijotomo, J., Siwalatri, N. K. A. and Setijanti, P. (2012) 'Meaning of Ornament in Balinese Traditional Architecture', *J. Basic. Appl. Sci. Res*, ***2***(7), 7121–7127. Available at: www.textroad.com.

Sala, N. (2003) 'Fractal Geometry And Self-Similarity In Architecture : An Overview Across The Centuries', *The International Society of the Arts, Mathematics, and Ardlitecture,* 235–244.

Sala, N. (2006) 'Fractal geometry and architecture : some interesting connections', *Eco-Architecture: Harmonisation between Architecture and Nature*, 86, pp. 163–173. doi: 10.2495/ARC060171.

Salingaros, N. A. (2019) 'The Biophilic Healing Index Predicts Effects of the Built Environment on Our Wellbeing', *Biourbanism,* ***8***(1), 13–34. Available at: http://zeta.math.utsa.edu/~yxk833/Biophilicindex.pdf%0Ahttp://www.biourbanism.org/the-biophilic-healing-index-predicts-effects-of-the-built-environment-on-our-wellbeing/.

Saraswati, A. A. A. O. (2002) *Pamesuan*. Jimbaran, Bali: Universitas Udayana.

Schumacher, T. L. (1987) 'The Palladio variations: On reconciling convention, parti, and space', *Cornell Journal Architect*, (3), pp. 12–29. Available at: https://cornelljournalofarchitecture.cornell.edu/issue/issue-3.

Sedrez, M. and Pereira, A. (2012) 'Fractal Shape', *Nexus Netw J, Relationships Between Architecture and Mathematics*, ***14***(1), 97–107. doi: 10.1007/s00004-011-0099-8.

Singh, A. K. *et al.* (2022) 'Investigating Architectural Patterns of Indian Traditional Hindu Temples through Visual Analysis Framework', *Civil Engineering and Architecture,* ***10***(2), 513–530. doi: 10.13189/cea.2022.100211.

Subrata, N. P. E. T. and Iskandar, M. S. (2021) 'An Analysing of a Balinese Traditional Gateway Design (Kori Agung) in Puri Agung Ubud, Bali', *The 4th International Conference on Business, Economics, Social Sciences, and Humanities*.

Subrata, N. P. E. T. and Kasmana, K. (2022) 'Design Analysis of Kori in Palebahan Ancak Saji at Puri Agung Ubud , Bali Design Analysis of Kori in Palebahan Ancak Saji at Puri Agung Ubud , Bali', *ARTIC*, ***4***(2), 391–400.

Sumadiyasa, I. K., Budhi Utama, I. G. S. and Yudabakti, I. M. (2020) 'Ornamen Karang Bhoma pada Bangunan Kori Agung di Kota Denpasar', *WIDYANATYA*, ***2***(1), 89–99.

Suryada, I. G. A. B. (2011) 'Varian-varian Ornamen di Bagian Atas Lubang Pintu Masuk Bangunan Gerbang Berlanggam Bali', *Jurnal Sulapa*, ***3***(1), 17–28.

Trivedi, K. (1989) 'Hindu temples: models of a fractal universe', *The Visual Computer*, ***5***, 243–258.

Vaughan, J. and Ostwald, M. J. (2011) 'Using fractal analysis to compare the characteristic complexity of nature and architecture : re-examining the evidence', *Architectural Science Review*, ***53***(3), 323–332. doi: 10.3763/asre.2010.0024.

Vaughan, J. and Ostwald, M. J. (2017) 'The comparative numerical analysis of nature and architecture: A new framework', *International Journal of Design and Nature and Ecodynamics*, ***12***(2), 156–166. doi: 10.2495/DNE-V12-N2-156-166.

Wina, M. *et al.* (2020) 'The Kori Agung Character of Heritage Temples : the Architectural References of Klungkung Identity', *Journal of Social and Political Sciences*, ***3***(1), 103–111. doi: 10.31014/aior.1991.03.01.151.

Wirawibawa, I. B. G., Putra, I. D. G. A. . and Aritama, A. A. (2022) 'Exploring Socio-Cultural Identity: Characteristic of the Architectural Design of Kori Agung Bangli', *Journal of Science and Political Sciences*, ***5***(1), 50–59. doi: 10.31014/aior.1991.05.01.335.

Wirawibawa, I. B. G., Putra, I. D. G. A. D. and Dwijendra, N. K. A. (2021) '"Memada-mada": The power relation and architectural creativity of gianyar palace', *Civil Engineering and Architecture*, ***9***(3), 949–957. doi: 10.13189/CEA.2021.090336.

Wiriantari, F. and Semarajaya, G. N. (2018) 'Perancangan Kori Agung', *Jurnal Anala*, ***6***(1), 73–82. doi: 10.46650/anala.6.1.586.73-82.