PRESERVING LOCAL ORNAMENT THROUGH ALGORITHM

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Abstract

This study employs fractal algorithms to generate and transform original Aceh ornaments into architectural design elements. The interpretation and generation of this ornaments by fractal method uses L-system based software called jBatik. We studied an approach of preserving local ornaments using three stages: understanding the local ornament geometry function, interpreting and generating new ornament using fractal method, exploring the possible iterations of patterns based on fractal algorithms. We applied this process into architectural design experiments where the 3D patterns used as an architectural design elements. The result shows that the possibility of preserving local ornament by fractal method can open opportunity for architects to explore new approach in design using the iteration and transformation of local ornaments. The endless possibilities offered by fractal method for generating new ornaments justify the digital advancement for its preservation.

Keywords: *fractal methods, local ornaments, jBatik, L-system*

Abstrak

Penelitian ini menggunakan algoritma fraktal untuk menghasilkan dan mengubah ornamen asli Aceh ke elemen desain arsitektur. Penafsiran dan pembuatan ornamen ini dengan metode fraktal menggunakan perangkat lunak berbasis L-system yang disebut jBatik. Kami mempelajari pendekatan pelestarian ornamen lokal dengan tiga tahap: memahami fungsi geometri ornamen lokal, menafsirkan dan menghasilkan ornamen baru menggunakan metode fraktal, menjelajahi kemungkinan iterasi pola berdasarkan algoritma fraktal. Kami menerapkan proses ini ke dalam eksperimen desain arsitektur di mana pola 3D digunakan sebagai elemen desain. Hasilnya menunjukkan bahwa kemungkinan untuk pelestarian ornamen lokal dengan metode fraktal dapat membuka kesempatan bagi arsitek untuk mengeksplorasi pendekatan baru dalam desain menggunakan iterasi dan transformasi ornamen lokal. Kemungkinan tak terbatas yang ditawarkan oleh metode fraktal untuk menghasilkan ornamen baru merupakan justifikasi kemajuan digital untuk pelestariannya.

Kata kunci: *metode fraktal, ornamen lokal, jBatik, L-system*

1. Introduction

One of significant issues in preserving local culture in modern context is the method to transform and codify its content using modern techniques without compromising the meta-information it contained [1-4].

Among other cultural heritages in Indonesia, Aceh ornament is one of the local legacy that could be preserved and revitalized in order to foster creative ideas for contemporary architectural design based on locality [5].

The fractal method is one of the possible approach to understand and to reproduce the patterns within the Aceh ornaments. This method can be utilized to transform original basic pattern into a new and innovative patterns without losing its identity [6-7].

Our study focuses on utilizing fractal method to gain understanding of Aceh ornament and to explore the transformation being produced. The goal of this study is to investigate the potentiality of fractal method to preserve local ornament which can contribute for the revitalization of local culture by digital technology.

2. The Ornament of Aceh

The ornament of Aceh is highly influenced by Islamic culture that came into the coastal kingdom around 15th centuries. Therefore, all ornaments are the manifestation of Islamic tradition which, according to Leigh (1989) categorized into five motives: geometry, vegetation, birds, animals and other Islamic patterns. Most ornaments being used for decorations are floral patterns and geometries since the representation of animals and human figures is prohibited in Islam.

At its principle, this ornament is based on simple geometry that being transformed by recursive iterations such as translation, rotation and others [8-9].
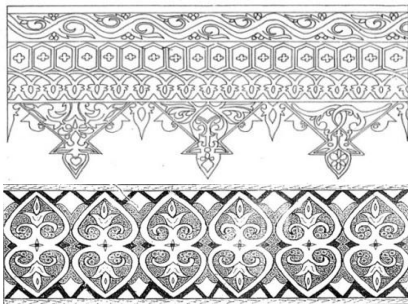

Fig 1. Example of Aceh Ornaments

Figure 1 shows the repetition of an original pattern that composes overall form of an ornament. The art of ornament is not only serve as a decorative form of visual language, but in the essence it contains the value of spirituality, education and morality [9].

The preservation of Aceh ornament in our study conducted using three stages as follows:
1. Understanding its original geometric iterations in mathematic functions.
2. Generating artificial pattern using fractal method with rules derived from original ornament.
3. Exploring the possible iterations of patterns based on fractal algorithms.

TABLE I
BASIC SHAPE OF ORNAMENT

Ornaments	Original Shape	Transformation

We choose an ornament for this study based on the local identity and the possibility of a new emerging pattern to be feasibly constructed as an architectural design element. Table I presents examples of original ornaments and interpretation of its original shape and basic transformation.

3. Fractal Generator

Fractal pattern is generated by mathematical function within recursive and iterative process in a finite or infinite sequence. This recursive or feedback loop is carried out using a piece of data and feedback in again repeatedly (Figure 2.).
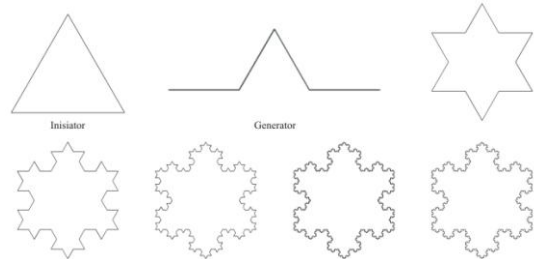

Fig 2. Producing fractal pattern using a triangle as inisiator and a generator as seen in von Koch curves above

The fractal pattern has four characteristics that exploited in this study namely [10-11]:
1. Self-similiarity; a part of the fractal is identical to the entire fractal or the pattern of a smaller scale is identical to the bigger scale
2. Self-affinity; an anisotropic transformation whereas a part of the fractal is scaled by different amounts in the x-, y- and z-dimensions.

One of the techniques for generating fractals pattern is by the L-system [12-13]. The L- system or Lindenmayer system is a formal grammal type of program which consist of variables and a set of production rules. The recursive nature of the L-system rules leads to self-similiarity and thereby the fractal-like patterns are generated.

The parametric form of L-system is defined as an ordered list as:

$$G = (V, \omega, P) \qquad (1)$$

Where: V (alphabet- variables) is a set of symbols of variable, ω (initiator) is a string of symbol from V defining the initial state, P (production rules) is a set of rules the way variables can be replaced.

A fractal pattern by L- system is produced by two parameters: initiator and generator. Initiator is an original state in form of a shape which will be iterated and generator composed of rules to modify the initiator. Generator produces a new

object that consist more than one copy of initiator and this rule applied to all new object recursively.

In this study we investigated the geometry of Aceh original ornaments using a program named jBatik [14]. jBatik is a software to generate batik patterns. Batik is a traditional patterns or ornament found on textiles in Indonesia originated in Java. The jBatik uses fractal, a branch of mathematic, to create batik patterns. The batik pattern itself has fractal characteristic, which is iteration and self similarities. Because batik is fractal in its seed, its derrivatives ornament can be modeled using mathematic functions. jBatik works by iterating the fractal formula loosely based on L-System. As such, the basic modeling is as follows:

Variables: A B
Initial state: A
Rules: (A→ AB), (B→A)
will produce in sequence order:

```
n=0:            A           =A
             /  \
n=1:        A    B           =AB
          /  |    \
n=2     A   B    A          =ABA
       /  |   |    |  \
n=3:  A  B   A   A   B   =ABAAB
```

TABLE II
EXAMPLE VARIABLE AND RULES IN jBATIK

Initiator	Rules	Remark	Visual
F	F	Draw a cylinder	
-	F-F	Rotate to the left	
+	F+F	Rotate to the right	
&	F&F	Rotate along Z-, toward user	
^	F^F	Rotate along Z+, toward computer screen	

The jBatik as fractal generator uses a geometry shape as variable and symbols to transform the variable and create new shape. The example of these basic symbols is depicted in Table II.

4. Fractal Pattern in Architecture

The application of pattern in architectural design mostly related with the building enclosure particularly the façade system. A façade is an outer secondary skin of a building that protect against excessive sunlight, rainwater, wind and other environment hazards [15].

In addition, the façade represents value, expression or statement of the building by providing a visual experience and attraction to the viewer.
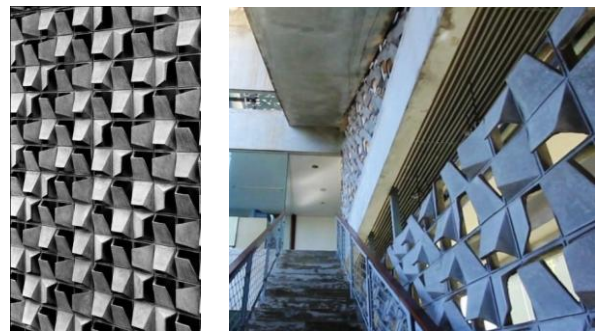

Fig.3. Pattern at the building façade
Source: Galery Salihara Photo

Figure 3 displayed a Salihara gallery in Jakarta by architect Marco Kusumawijaya in which expression of the façade represents building function as an office and art gallery. The innovative pattern of the façade used as a sound barrier as well as a sun shading device.
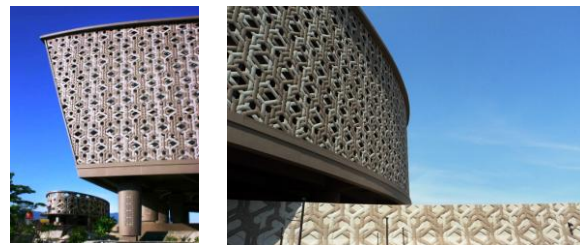

Fig.4. Pattern of Tsunami Memorial and Museum
Source: Competition Documents, IAI Aceh

Figure 4 is another example of the pattern application in a building façade. The interpretation of local pattern of Saman dance into two dimensional pattern expresses the culture of Aceh in a museum and memorial park for Tsunami disaster by architect Ridwan Kamil [16].
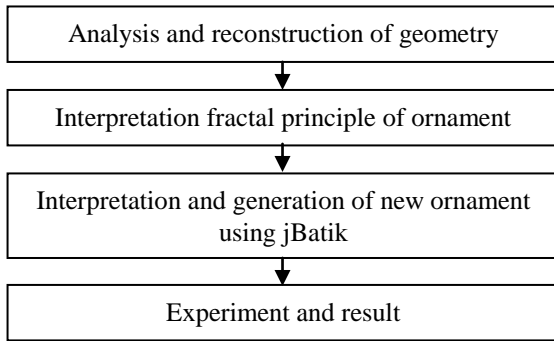
5. Methodology

Analysis and reconstruction of geometry

↓

Interpretation fractal principle of ornament

↓

Interpretation and generation of new ornament using jBatik

↓

Experiment and result

Fig 5. Global block diagram of the methodology

5.1. *Analysis and reconstruction of geometry*

The first stage of this study is analysis and reconstruction of Aceh ornament using tracing technique in CAD. In a two dimensional, black and white image, the interpretation of its shape validated through visual closeness with the original one using transformation rules that being common used in local pattern such as reflection, rotation, linear translation. This transformation rules is recorded to be reference in later fractal rules. Figure 6-7 shows the basic 2D interpretation of two of the ornaments being studied.

5.2. *Interpretation fractal principle of ornament*

The method of interpretation fractal principle by the following procedures:
1. Generator and initiator analysis of ornaments forming.
2. Elaborate the structure of the ornaments to be the smallest part of the ornaments forming structure elements.
3. Fractal principles analysis of geometry that occurs in the iteration process.

Particular in Bungong Selanga pattern, the self- similiarity and self-affinity principles interpreted as a rules to arrange and combine smallest petal by applying anisotropic transformation of repetition with scale, rotation, reflection and linear translation. Figure 8 shows the iterative process of the pattern.

5.3. *Interpretation and generation of new ornament using jBatik*

The method of interpretation conducted by the following procedures:
1. Interpretation of the smallest part of the seed

and looking for the possible fractal principles can be applied
2. Interpretation of the transformation and iteration using rules
3. Generation and combination of the result into new ornament
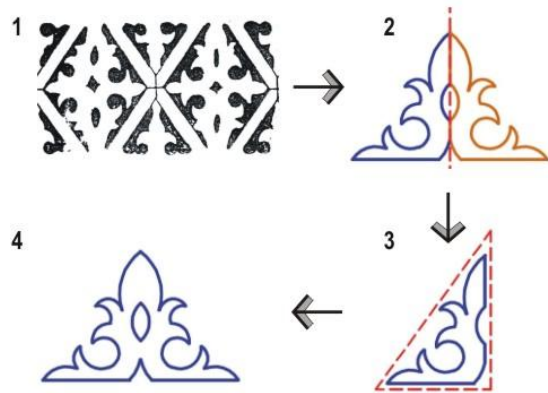
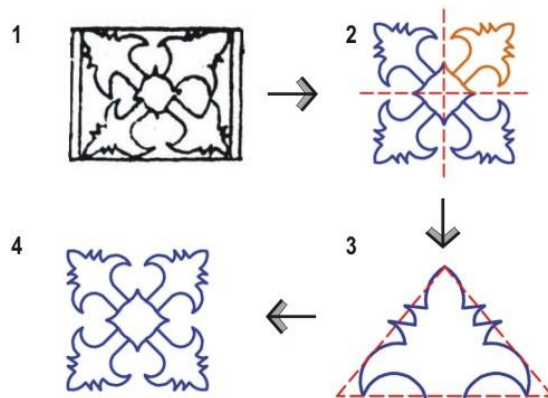Fig 6. 2D Reconstruction of Pucok Reubong ornament

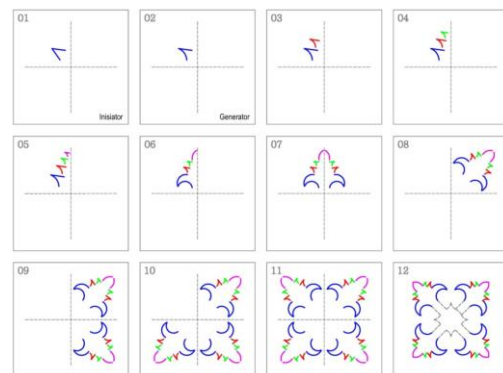Fig 7. 2D Reconstruction of Bungong Seulanga ornament

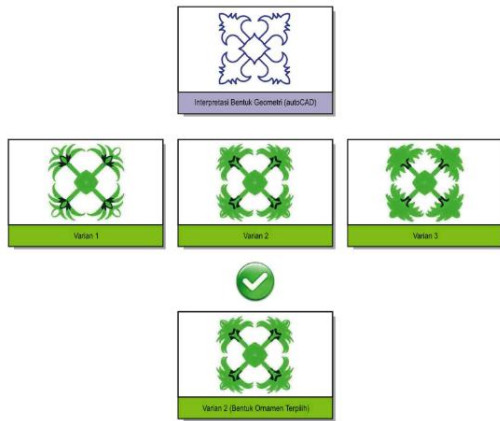Fig.8. Interpretation of fractal principles

Fig.9. Original interpretation of local ornament and three new ornaments generated by fractal methods

Furthermore, the process of generating desired pattern through L-system based in jBatik generator explained as below (Table III-IV):

Variable: A=[+g.}{].fA
                 B=[-g.}{].fB
Parameter:
       Num. of iteration : 1
       Angle   : 45°
       Length   : 10
       Width   : 1
Rule:
       [cA}][B}] on Var A

TABLE III
RULE: [CA}][B}] ON VAR A

Proc.	ω	Rem.	Result
(1)	[	Defined first point	
(2)	+	Draw line g to the right with angle 45°	
(3)	g	Draw a line	
(4)	-	Record second point	
(5)	}	Draw a polygon	
(6)	{	Stop draw a polygon	
(7)	]	Back to first point	
(8)	-	Record third point	
(9)	f	Draw a second line	
(10)	fA	Itarate number of created polygon	

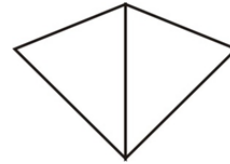Result of this procedures generate a shape as follow (Figure 10.):

Fig.10. Basic shape generated by simple rules in jBatik

TABLE IV
RULE: [CA}][B}] ON VAR B

Proc.	ω	Rem.	Result
(1)	[	Defined first point	
(2)	-	Rotate line g to the left with angle 45°	
(3)	g	Draw a line	
(4)	-	Record second point	
(5)	}	Draw a polygon	
(6)	{	Stop draw a polygon	
(7)	]	Back to first point	
(8)	-	Record third point	
(9)	f	Draw a second line	
(10)	fB	Itarate number of created polygon	

To the extent, jBatik generates numbers of derivatives shapes based on the number of iterations (n) as follows (Table V):

TABLE V
BASIC ITERATIONS

n=2	n=3	n=5

6. Experiments and Result

In this section we present explorative experiments on generating ornaments using jBatik as fractal generator. To the extent of two dimensional ornament as described in previous section, we did the experiment in three dimension as presented below (Figure 11-13). We choose Bungong Seulanga pattern as a references in which fractal-based generated pattern emerges.
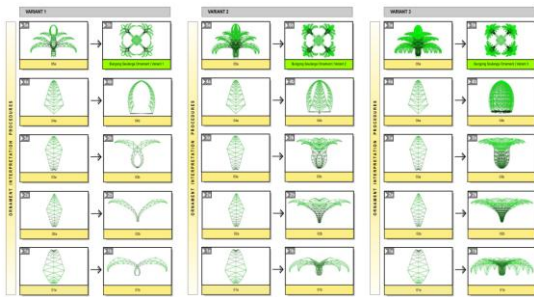

Fig 11. Original interpretation of local ornament and three new ornaments generated by fractal methods

As the new ornament will be used as three dimensional architecturel panel, the interpretative process of new ornaments are developed based on its constructibility in addition to the visual representation of local identity. Figure 12 depicts generation of three dimensional form of fractal-based pattern. The codification and transformation of each sepal and petal taking cues from the real-life references of each ornament which is a local flower (Bungong Seulanga)
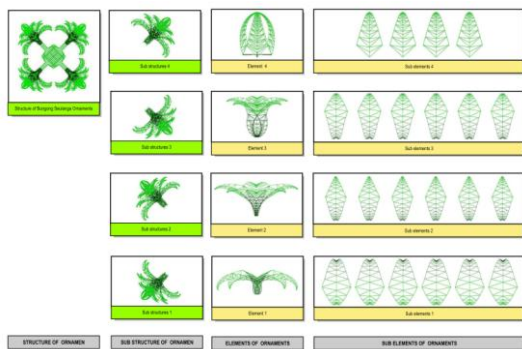

Fig 12. Process generating a complex 3D ornaments based on fractal methods

Furthermore, following the codification of ornament, we developed series of architectural element alternatives using parts of the generated ornament. The part used in this experiment is which one has constructibility characteristic to be developed as architectural element.

In this example, we elaborated a petal of Bungong Seulanga and generated array of a new pattern-based form in which applied as a design of a roof elements (Figure 13).
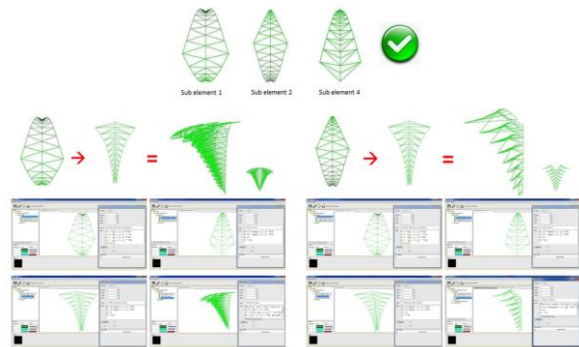

Fig 13. Exploration and development of 3D ornament

Once the 3D patterns formed in jBatik, the follow up process is to elaborate the model according to the architectural design process using a 3D modeling software. Architectural design process commonly refers as a quasi-sequential process where anything that inspired designer through subjective judgement can be valued as an approach for creating a design within a sequential creative process.

The pattern created based on fractal method therefore can be used and adjusted to fill in the space in the process. The experiment conducted to use the generated pattern as a basic design for a roof element as seen in Figure 14-15.

The result of each experiement is only limited by the subjective judgement from the user which is indicated by:

1. The overall pattern still be recognized as a local Aceh ornament
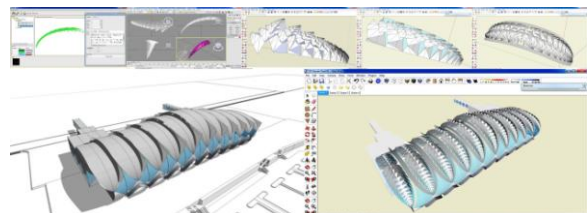2. The overall pattern can feasibly constructable.

Fig 14. 3D modeling process taking part from jBatik

Fig 15. 3D architectural modeling utilizing 3d ornament generated in jBatik

7. Discussion

This study initially has purpose in investigation of fractal method to interpret and to develop a local ornament which later on can be utilized as a pattern generator used for architectural design process. At the side note, L-system based fractal generator we used in this study is capable to reconstruct and further generate new local patterns at a degree which is unrecognizable as local ornament.

We advised the utilization of fractal algorithm as a digital preservation method be used under the supervision from local expert in order to keep the identity and meaning of local ornament intake. Although algorithm could interprete rationalization of vernacular ornaments, there are some aspects such as irregularities that mostly be valued as human craft that cannot be replaced.

On the other hand, using a proper limit of iterations, fractal algorithm can be used as an enabler of creativity process for architectural design where it demands a novel shape or form that generated through an emerging process. A modern transformation of local ornament therefore, made further possible in a fashion that architect could take a role in creating such innovative design based on locality.

Acknowledgment

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