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FRACTAL MOTIF OF 'GARUDA NGUPUK' IN LOKATMALA BATIK DESIGN WITH SUNDANESE SCRIPT

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ABSTRACT

In traditional Indonesian batik, intricate designs reflect the nation's rich heritage. This study explores the use of fractal geometry, specifically the 'Garuda Ngupuk' motif, in evolving Lokatmala Batik designs known for their complexity and elegance. Inspired by Sundanese script, this research paper highlights how fractal curves can rejuvenate traditional batik artistry. Using digital design techniques alongside traditional craftsmanship, the study creates intricate Lokatmala Batik patterns that merge Sundanese cultural essence with modern geometric motifs. This fusion of tradition and innovation showcases Lokatmala Batik as a testament to the enduring beauty and adaptability of this Indonesian cultural heritage on a global stage.

2020 Mathematics Subject Classification:
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Introduction

In the 20th century, the art of batik-making flourished in several regions of West Java, such as Cirebon (Trusmi), Indramayu (Paoman), Ciamis, Tasikmalaya, and Garut, with each region developing its own unique patterns and motifs [1]. These distinct styles have led to the recognition of specific regional batik identities. Similarly, "Lokatmala Batik" from Sukabumi has developed its own distinct style. The motifs of Sukabumi batik are deeply rooted in the local lifestyle and the surrounding natural environment. Consequently, each batik pattern holds significant meaning. There are at least 20 different Lokatmala Batik motifs from Sukabumi, including Sukabumi Masagi, Candramawat, Leungli, Garuda Ngupuk, etc. [2] (as shown in Figure 1).

Figure 1: Some of Lokatmala Batik Motifs, originally from Sukabumi, West Java, Indonesia

The Garuda Ngupuk motif (Figure 2), for instance, draws inspiration from the nesting habits of the Garuda bird and is a basis for the spatial planning concepts used in the development of government centres. This motif embodies the principle encapsulated by the phrase "Garuda ngupuk, bahe ngaler-ngetan, deukeut pangguyangan badak putih," which states that the ideal location for establishing a capital city must near a water source and have excellent overall attributes. The philosophy of the Garuda Ngupuk batik emphasises that every individual should be well-read and knowledgeable, as knowledge is the foundation of life. It also places an emphasis on being dynamic and adaptable and possessing a strong heart to face any challenge or adversity.

Figure 2: Garuda Ngupuk motif

Our study aims to create a modern motif using fractal technology on traditional Lokatmala Sukabumi batik, specifically the Garuda Ngupuk motif, with a palette that incorporates Sundanese script. The research methodology used to achieve this is discussed in Section 2. Sections 3 and 4 review related manuscripts and theories behind implied fractals in Batik design. The next two

sections discuss the significance of fractals in the Garuda Ngupuk motif of Lokatmala Batik, and the limitations and future research direction of this research paper before discussing its conclusions.

Literature Review

Preservation of Lokatmala Batik Sukabumi

The preservation of Lokatmala Batik Sukabumi involves recognising and maintaining the unique motifs that form its foundation. Plants, humans, animals (such as turtles, fish and the Garuda), and water patterns are integral Lokatmala Batik Sukabumi motifs [13]. Each of these elements carries a cultural significance and has artistic value, which reflects the rich heritage and natural beauty of the Sukabumi region. Intelligent design technology plays a crucial role in safeguarding and promoting these traditional patterns. The technology is used to generate digital patterns that not only aid in the preservation of traditional batik but enrich the diversity of batik patterns. By digitising these motifs, the intricate details and cultural narratives embedded within each design can be meticulously documented and preserved for future generations [14].

Furthermore, the use of intelligent design technology will allow for the adaptation of traditional motifs to contemporary designs, ensuring their relevance in modern fashion and art. This integration of traditional and modern elements will help maintain the cultural essence of Lokatmala Batik Sukabumi while making it accessible and appealing to a broader audience. In addition to preserving this artistic heritage, the use of digital technology will facilitate the creation of new designs inspired by traditional motifs. This approach not only expands the repertoire of batik patterns but also encourages innovation and creativity among designers. By leveraging technology, designers can experiment with various elements, colours, and compositions, creating unique and personalised batik pieces. Moreover, the digital preservation of batik motifs supports educational initiatives, enabling the dissemination of knowledge about batik art and its cultural significance. Digital archives and design tools can be used in educational programmes to instruct students and enthusiasts about the historical context and intricate processes of batik making.

Overall, the preservation of Lokatmala Batik Sukabumi through digital technology not only ensures the continuity of this traditional art form but also promotes its adaptability and evolution in the modern era. This blend of tradition and innovation serves to honour the cultural legacy of Sukabumi while fostering a dynamic and sustainable future for batik art.

L-System Command

The digitalisation method used involves turtle drawings and mathematical designs. Turtle drawings are used to create arbitrary batik motifs, while mathematical designs are used for motifs that can be defined with mathematical equations. Initially, the batik motif is sketched on paper before formulating the corresponding equation. The method of digitalisation implemented uses turtle drawings and mathematical designs [15]. The turtle's state is represented as a triplet (x, y, α), where (x, y) are the Cartesian coordinates of its position and α is the heading direction. With a step size d and an incremental angle δ, the turtle follows commands symbolised.

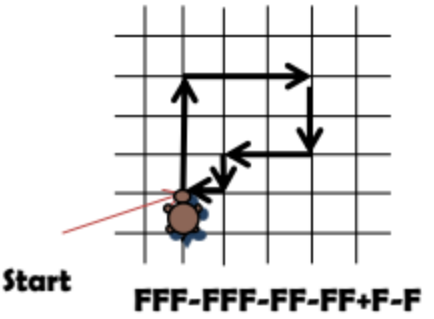

Figure 3: Explanation of a string: When the angle δ is augmented, it reaches 90◦. At the start, the turtle is oriented in an upward direction.

For instance, in Figure 3 the turtle starts by facing upwards, moves forward three steps, rotates 90 degrees right, moves forward three steps again, rotates right 90 degrees, and continues in this manner following a specific sequence of steps and rotations. This command can be abbreviated as FFF-FFF-FF-FF + F-F (Completely on Table 1).

Table 1: Turtle graphics commands for L-System

Symbol	Interpretation
f	Move forward and draw a line
F	Move forward without drawing a line
-	Turn left with the angle δ.
+	Turn right with the angle δ.
I	Turn around (rotate 180 degrees)
[	Save state
]	Restore state
>	Increment colour
<	Decrement colour
{	Increase the line thickness
}	Decrease the line thickness

The creation of batik motifs has seen significant advancements, evolving from traditional hand-drawing methods to incorporating fractal geometry, a branch of mathematics [3]. Fractal geometry studies the behaviour and properties of fractals, which are non-linear shapes not defined by traditional Euclidean geometry. Mathematically, a fractal is a set of points with a dimension greater than its topological dimension. Fractal batik involves designing batik patterns using mathematical formulas executed through computer technology. Initially, batik motifs are transformed into mathematical formulas using L-Systems [4]. These formulas are then modified by changing their parameters, resulting in more complex and intricate designs. This process produces distinct batik patterns that differ from the original by altering the formula's parameters [5].

Several studies have explored fractal batik, including the work of Purnomo et al [6]. Wulandari (2017) [7] combined fractal geometry and Batik Labako by first drawing the Labako motifs using Corel Draw, generating fractals with L-System, and then merging and modelling them. In this research, the development of Batik Labako motifs was carried out by generating leaf patterns using L-System and combining them with the fractal geometry of the Dragon curve, modelled using geometric transformation techniques in the Matlab software. The geometric batik motifs can be created using an automatic method based on the iterative function system (IFS) [8] of fractal geometry. However, geometrically symmetrical batik like printed batik often has a lower market value compared to traditional hand-drawn batik [9]. This method can effectively emulate traditional hand-made batik.

The application of digital technology in designing traditional batik patterns can significantly enrich batik motifs. Kosala Purnomo [10] proposed combining a fractal matrix iteration using Koch snowflake geometry, generating a "parang rusak" fractal patterns by setting the number of iterations and evolutions. Ratnadewi [11], The batik motif shape, size and position are formulated into mathematical equations, implemented into the form of computer graphics (turtles) graph and explained in the form of an algorithm (pseudocode) computer programming to automatically generate Purwakarta batik motifs that did not exist before. Widia Bastaman [12] using jBatik application to designs of kerancang embroidery motif compositions inspired by chrysanthemum flowers, lotus flowers, and phoenixes. These motifs are in bold or bright colours and are combined with soft colours to match the character of kerancang kebaya.

JBatik Application

In this modern era, the conversation about batik has extended beyond the philosophical, and evolved into a contemporary trend. One significant aspect of this trend is the use of technology. Consequently, the batik industry is adapting to technological advancements to stay relevant and competitive in today's market. In response to these challenges, the Pixel People Project developed specialized design software for batik motifs called jBatik in 2006. This software led to the creation of "Fractal Batik," a brand characterised by fractal elements—self-similarity in geometric detailing at smaller scales. jBatik aims to assist the Indonesian batik industry in evolving traditional motifs through the application of advanced design techniques.

JBatik is a software designed for creating batik motif designs using fractal formulas, a branch of mathematics that studies repetitive processes as written by Heurteaux & Jaffard [16] . With jBatik, artisans can develop modular batik motifs and create new compositions in various variations [17]. The software offers features that facilitate the precise adjustment of curves, distances, and sizes. There are two versions of jBatik software: jBatik Basic and jBatik Pro, each with its own advantages. jBatik Basic is used to create two-dimensional (2D) motifs and combine modular motifs already available in the software. Meanwhile, jBatik Pro not only can create 2D motifs but also can produce three-dimensional (3D) motifs. These 3D motifs have thickness and can be viewed from multiple angles, including front, back, left, right, top, and bottom, providing richer variety and dynamism compared to other design software [18]. Beside in Indonesia, jBatik has also been used to reproduced Tudita-Turkish motif [19].

From 2017 to 2019, tests on traditional Tuban motifs using jBatik produced numerous new variations [20], significantly differing from the original motifs in terms of decoration and overall

appearance. The motif applications from jBatik application have extended beyond fabrics to various fashion products such as clothing, bags, and shoes, showcasing its versatility. This development demonstrates the software's potential to not only preserve but to innovate traditional batik designs, ensuring that batik remains a vibrant and relevant part of modern fashion.

Research Methodology

The research methodology for developing Lokatmala Batik motifs involves several stages, each critical to the final design. A detailed explanation of the steps involved is outlined below:

Stage 1: Making Sunda Script into Library Palletes

The initial stage involves making a Portable Network Graphic (.png) library of Sunda script characters. This process can be done by manually drawing the characters in some programs. In this research the motifs are developed by combining three Sunda scripts as depicted in Figure 4.

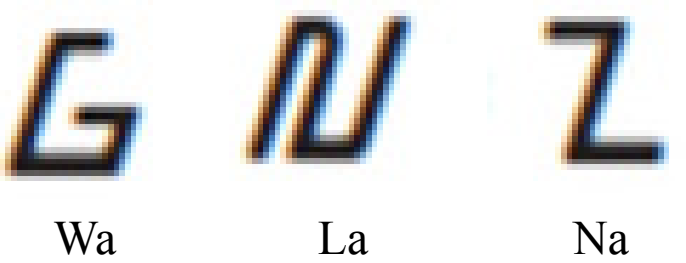

Figure 4: Three Sunda Consonants Traditional Script with their spelling (Wa, La and Na)

Stage 2: Generating and Modelling the Garuda Ngupuk Motif with L-System

The second stage focuses on generating and modelling the Garuda Ngupuk motif. This is achieved by using L-System. This process requires defining the starting point, the angle of turns, setting the axiom, and determining the production rules. These elements are essential for the algorithm to produce the intricate traditional Lokatmala Batik designs, symbolising the cultural significance of the Garuda.

Stage 3: Designing the Fractal of Lokatmala Batik

In the third stage, the Lokatmala Batik pattern is designed by integrating the Garuda Ngupuk motif with the Sunda script. The arrangement of these motifs is meticulously structured in vertical, horizontal, and diagonal orientations. This design process leverages geometric transformations such as rotation, reflection, translation, and dilation to achieve a cohesive and aesthetically pleasing pattern. This integration is tailored to the specific batik pattern being designed, where each section is given options for different motif fillings, including variations of the Garuda Ngupuk motif and Sunda scripts patterns. The program uses the parameters set in the earlier stages to seamlessly combine these elements into a unified batik design.

Results and Discussions

Generate Fractal Geometry for Garuda Ngupuk Motifs using L-System

At this stage, the Garuda Ngupuk motif will be rearranged into a fractal form using the L-System. The process begins by utilizing the sketch in Figure 5, then approximating it with fractal equations facilitated by the jBatik application.

Figure 5: Garuda Ngupuk Sketch

From the sketch in Figure 5, it is evident that the components of the Garuda Ngupuk motif, derived from the Garuda bird's form, include the head, wings, body, and tail. Using the jBatik software, this researcher managed to obtain the L-System equations for each component, illustrated in Table 2.

Table 2: The L-System of Fractal Design

Component	Axioma	Detail	Iteration	Angle
Left wing	0.3887)"(0.3887)+(-190.38)|A	A=F;+"?A	3	53
	?(0.274)"(0.274)+(228.56)B	B=F;+"?B	3	29
	?(0.3887)"(0.3887)+(68.23)A	C=F;+"?C	5	29
	?(0.2766)"(0.2766)+(-119.7)|A	D=F;+"?D	3	53
Tail	?(0.3302)"(0.3302)+(-523.4)AB	A=F!(1.1)'(1.06)-A B=F!(1.1)'(1.06)+B	8	2
Left body	?(0.3887)"(0.3887)+(68.23)A	A=F;+"?A	13	29
Right body	?(0.5172)"(0.5172)|+(-277.57)A	A=F[-f]-A	13	-15
Head	A=F[-F]{+F]	A	0	0

Designing the Fractal of Lokatmala Batik with Garuda Ngupuk Motif

The Sundanese script is converted into PNG format and then inserted into the palettes of jBatik. Once each component is formed into a fractal shape using Table 2, the next step is to arrange the batik pattern. Some components in Figure 5 are translated into fractal form using L-System equations with appropriate axioms, definitions, and iterations, but there are also components like the Garuda Ngupuk motif that are manually created using the GUI provided by jBatik. For methods using the GUI, the L-System equations can be viewed through the text editor provided by jBatik. The batik pattern, which takes the form of an image with symmetry and composition adapted to the

sketch in Figure 5, is given a touch of colour and additional ornaments to make it more modern and different from its traditional form as shown in Figure 6.

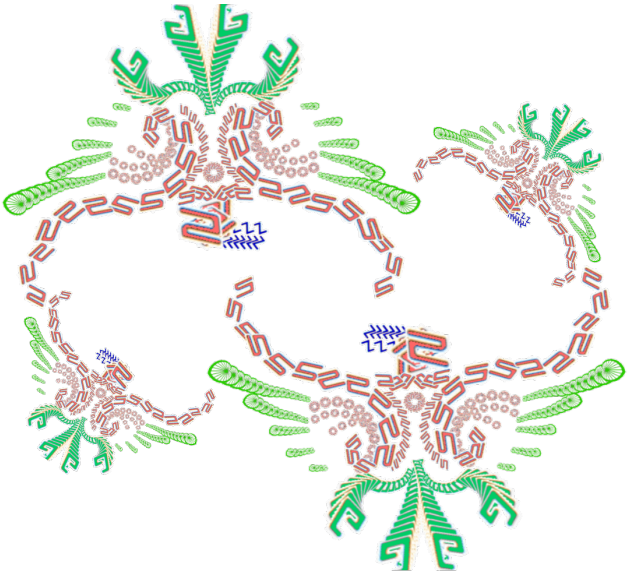

Figure 6: Batik design for Garuda Ngupuk motif using fractal

Enhancements in technical explanations and deeper analysis provide a clearer understanding of the design's impact and innovation compared to traditional batik methods.

Conclusions

The conclusion of this research reveals that the simple combination in creating the Garuda Ngupuk Bird motif in a basic fractal form has been successfully realized through the use of modern technology. The application of L-System and jBatik software demonstrates that fractal technology can be effectively utilized in the creation of Lokatmala Sukabumi batik patterns. This technique leverages elements such as angles, axioms, definitions, and Lindenmeyer rules to craft designs that are both complex and structured.

The study also shows that each batik ornament can be filled with three Sundanese characters that can be varied according to the artist's creativity while still adhering to the traditional principles of the Garuda Ngupuk Bird motif. Thus, fractal technology not only serves as a design tool but also as a means to preserve and develop cultural heritage through innovation in batik design. It can add business value to Lokatmala Batik. This research opens up opportunities for batik artists to merge tradition with technology, creating artworks rich in cultural and aesthetic value, and relevant to contemporary developments.

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Conflict of Interest Statement

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