Application of fractal principles in redesigning an arabic calligraphy and rafflesia flower motif in Batik Besurek

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Abstract. Batik besurek is one of Indonesia's cultural heritages from Bengkulu Province. This batik is different from another batik in general because it has the characteristics of Arabic calligraphy. There are seven types basic of motifs in batik besurek, one of them is the Arabic calligraphy motif. In this paper explained the development of the pattern of the Arabic calligraphy and rafflesia flower motif in batik besurek. The pattern development is done by applying the fractal principles. The results is a new motif of batik besurek that are expected to enrich the style, shape, diversity of motifs, and enhance the beauty and selling value of the batik itself.

1. Introduction
Batik is a characteristic of the Indonesian nation that is already quite well known internationally. Some regions in Indonesia also have batik which has different characteristics. One of them is Bengkulu Province which has a batik known as batik besurek cloth or often referred to as batik besurek. The name "besurek cloth" comes from the Bengkulu language, "be", including the prefix with the understanding "ber" and "surek" which means "letter" or "writing". Besurek means cloth that has been filled with letters or writing characterized by Arabic calligraphy writing [1]. Batik besurek has been designated as one of Indonesia's cultural heritages from Bengkulu Province in 2015 [2].

As one of Indonesia's cultural heritages, Bengkulu Provincial Government is increasingly aggressively promoting batik besurek. One of the ways is by holding an international batik besurek festival. The participants of which are not only Bengkulu residents but also people outside Bengkulu and even abroad. The aim is to further increase the love of Bengkulu people for batik besurek and introduce batik besurek to people outside Bengkulu and even abroad. In order for this government goal to be realized, it is necessary to develop other motifs of batik besurek so that it enriches its style, shape, diversity of motifs and can add to the beauty and selling value of batik itself while still maintaining its basic motifs and not eliminating the implied symbols in it.

There are seven types of motifs in batik besurek. These seven motifs have symbols that are implied and contain meaning, important and deep philosophies and vary so that even in their use and placement not all motifs can be used freely. One of the basic motifs of batik besurek is Arabic calligraphy motif. Besides Arabic calligraphy, rafflesia flower is a motif that is found in many batik besurek motifs. This is because rafflesia flower is one of the characteristics of Bengkulu City and is the largest flower and only grows in the forests of Bengkulu Province. The development of the batik
besurek motif can be influenced by other characteristics of batik, which is self likeness or known as fractals.

Fractals are rough geometric objects at all scales, and appear to be "divided" in a radical way. Some fractals can be broken up into sections that are all similar to the original fractal. Fractals are said to have infinite detail and can have self-similar structures at different magnification levels. In many cases, a fractal can be generated by repeating a pattern, usually in a recursive or iterative process. Fractal geometry is a branch of mathematics that studies the properties and behavior of fractals. Fractals can help explain many situations that are difficult to describe using classical geometry, and have already been applied quite a lot in science, technology, and computer art.

The main issue of this paper is to redesigning the batik besurek motif with the focus is Arabic calligraphy and rafflesia flower motif by applying fractal principles.

2. Batik and Batik Besurek
Batik is a pictorial fabric that is made specifically by writing or applying wax on the fabric, then processing it in a certain way or commonly known as batik cloth [3]. Based on its etymology and terminology, the term batik comes from Javanese language which is a series of words "mbat" which means to blow or throw repeatedly and "tik" which means point. So, batik means throwing dots repeatedly on the fabric. Others say that the word batik comes from the word "amba" which means wide fabric and the word dot. This means that batik is the points drawn on a wide cloth medium such that it produces beautiful patterns. Batik has characteristics on motifs and patterns. Batik motifs consist of elements of the main motifs, supporting motifs, and content (stuffing) that become a single unit so that realize batik as a whole [4]. Batik has distinctive features that are different in each region, for example batik Cirebon, batik Pekalongan, batik Solo, batik Jogya, batik Bengkulu and other batik which of course have very different patterns and motifs.

Batik Bengkulu is known as batik besurek. At first, batik besurek was used for traditional ceremonial equipment such as marriage ceremonies, births, deaths, and other traditional ceremonies. However, along with the development of the age of batik besurek is currently made in other practical forms such as robes, head scarves, wall hangings and other forms. The forms and motifs of batik besurek are different from the forms of other batik motifs. The form and motifs of the batik besurek are characterized by Arabic calligraphy and has a certain philosophy. Picture 1 shows some batik besurek motifs. These motifs are the basic motif of batik besurek [5].

Figure 1. Some batik besurek motifs.

There are seven types of basic motifs of batik besurek, namely: Arabic calligraphy motif, rembulan and Arabic calligraphy motif, Arabic calligraphy and jasmine flower motif, kuau bird motif, the combination of hayat and kuau birds motif, clove flower and cempaka flower motif, and Arabic calligraphy for punai bird and niche motif [6]. These motifs have symbols that are implied and contain
meaning, important and deep philosophies and vary, so that even in their use and placement not all motifs can be used freely.

3. Fractal
Fractal comes from the Latin "Fractus" which means "broken", damaged "or irregular. Fractal geometry is a workable geometric middle ground between ground between the excessive geometric order of Euclid and geometric chaos of general mathematics [7]. Fractals are geometric objects that are rough on all scales and can be "divided" in a radical way. Some fractals can be broken up into sections that are all similar to the original fractal. Fractals are said to have infinite detail and can have a self-similar structure at different magnification levels [8]. Fractal objects and processes are said to display "self-invariant" (self-similar or self-affine) properties [9]. A fractal object could be defined as a fragmented geometric shape that can be subdivided in parts, each of which is approximately a reduced-size copy of the whole [10]. In many cases, a fractal can be generated by repeating a pattern iteratively or recursively. One of fractal shape that is quite well known is Von Koch snowflake. Figure 2 shows the construction of Von Koch curve proceeds in stages, The outline of Koch snowflake (also called Koch island) is composed of three congruent parts, each of which is a Koch curve [11].

![Figure 2. Von Koch snowflake and Von Koch construction.](image)

Various types of fractals were initially studied as mathematical objects that can be measured by ordinary mathematical calculations. There are many mathematical forms which are fractal shapes, for example the Sierpinski triangle, Koch snowflake, Peano curve, Mandelbrot set and Julia set. Fractals are also found in objects in the real world such as clouds, mountains and coastlines that have complicated geometric shapes. In general, irregular fractal forms are non-linear forms as in the general mathematical form.

Currently fractal forms have been widely applied in various fields of science, technology and computers. The existence of fractals can produce works that have high artistic and intellectual value. Figure 3 shows some well-known fractal shapes.

![Figure 3. Sierpinski triangle, Julia set and Mandelbrot set.](image)
4. Results and discussion

4.1. Research procedure
Steps of this research procedure are:
- a. Observation and data collection
- b. Study the literature on fractal geometry and linear transformation
- c. Design batik besurek motif by using a principles of fractal and linear transformation
- d. Analyze the resulting batik besurek motif

4.2. Data availability
Data used for this research are primary data obtained through direct measurements and secondary data obtained from relevant agencies or previous studies. Based on interviews at several batik besurek sentra and cloth shop that sell batik besurek in Bengkulu City, batik besurek motifs that are quite popular with consumers are motifs that contains images of rafflesia flowers that are characteristic of Bengkulu City.

4.3. The Arabic calligraphy and rafflesia flower motif
This research develop a new pattern batik besurek motif, that is Arabic calligraphy and rafflesia flower motif. Figure 4 and Figure 5 shows some the Arabic calligraphy motifs rafflesia flower motifs.

![Figure 4. The Arabic calligraphy motifs.](image1)

![Figure 5. The rafflesia flower motifs.](image2)

4.4. Design Batik Besurek Motif by using a principles of fractal
The first step in developing batik besurek motif is drawing the ornaments that will be developed. Figure 6 is the basic motif to be developed namely Arabic calligraphy and rafflesia flowers.
The second process in developing batik besurek motif is done by repeating the motif ornaments with different dimensions/sizes, in this paper the dimensions taken are $\frac{1}{2}$ (Figure 7).

The third process in developing batik besurek motif is done by reflection Figure 7 in the vertical line (the $y$-axis) and the results shown in Figure 8.
Figure 8. Design of batik besurek motif by repeating the motif ornaments with dimension $\frac{1}{2}$ and reflection in the vertical line (the y-axis).

The fourth process in developing batik besurek motif is done by add the Arabic calligraphy ornaments and using the fractal principle with dimension 1 on Figure 8. The results were obtained as shown in Figure 9.

Figure 9. Design of batik besurek motif by add the Arabic calligraphy ornaments and using the fractal principle with dimension 1.

The fifth process in developing batik besurek motif is done by reflection Figure 9 in the vertical line (the y-axis) and horizontal line (the x-axis) and the results shown in Figure 10.
In this paper, Figure 10 is the final result of the process of developing batik besurek motif using the principle of fractal geometry and linear transformation. The next step is to realize this design into batik by making a mold based on the design in Figure 10 or it can be realized in the form of a written batik.

4.5. Analyze the resulting batik besurek motif
The indicator established in the analysis of the results is the existence of characteristic self-similarity of fractal principle in the specified dimensions. Based on the results obtained, it is clearly seen that the characteristic self-similarity of fractal principle in dimensions 1 and ½.

5. Conclusion
The principle of fractal geometry that has an infinite shape and can have a self-similarity structure at different magnification levels and the properties of linear transformation can be used to design new motifs in batik besurek. New motifs batik besurek produced can enrich the style, shape, diversity of motifs, and enhance the beauty and selling value of batik itself. In addition, by the characteristic self-similarity of fractal principle, the resulting motifs will maintain its basic motifs and not eliminate the implied symbol in it. The development of batik besurek motifs using the principle of fractal geometry can continue with the help of a computer program, so that batik besurek will further develop and remain sustainable.

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