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Application of Turtle Graphics to Kawung Batik in Indonesia

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Kawung Batik is the oldest batik motif. There are three versions of the origin of kawung batik: First, in the Mataram kingdom, there was a clean-hearted, very wise and polite young man who was the Duke of Wonobrodo. At the time of his appointment, he used Kawung batik. Second, there is a dark brown beetle that disturbs coconut trees. The shape of the Kwangwung beetle is an inspiration for the kawung batik motif, such as in Figure 2. The third version is the palm fruit or kolang kaling, which looks symmetrical like batik kawung. Various forms of kawung batik motifs exist in Indonesia. Archiving of kawung batik motifs can be done using turtle graphics, so storage is simpler and requires less memory. The results of kawung batik motifs raised with turtle graphics can be used as preliminary drawings before making batik by hand or with a stamp so that it is beneficial for batik productivity. In this paper, we present kawung picis, kawung bribil, and kawung sen. Each kawung batik motif is formed with a different turtle graphic equation. This can be seen in the pseudocode of each motif. If the shape is almost similar, then the pseudocode can be the same, but if the shape is different, then the pseudocode will also be different. The addition of the motif needs to be followed by another turtle graphic equation. As a comparison, canny edge detection can be used to obtain kawung batik motifs. With the turtle graph, all batik isen-isen can be described. Future studies of turtle graphics are expected to be applied to other motifs.

Keyword: *Kawung batik, Turtle graphics, Motif*

Introduction

In ancient times, Batik kawung was only used by the royal family (Van Roojen, 1997). This motif reflects the personality of a leader who can control passions and keep a clear conscience to form a balance in the behaviour of human life (Parmono, 2013). There are 3

versions of the origin of kawung batik: First, in the Mataram royal era there was a very wise and polite young man with a clean heart who was respected by his people. The kingdom invited the young man because of his fame. Young mothers were very happy and made batik with kawung motifs, with the hope that this man could become a useful figure for the community. Finally, the young man was appointed Duke of Wonobrodo, who at the time of his appointment was using his mother's kawung batik (Rosanto, 2009).

The third version is the palm fruit, or the sugar palm pod, whose composition consists of a dark brown seed coat and clear white fruit, as seen in Figure 1. The symmetrical shape is the inspiration for kawung batik.

Figure 1. **Kolang kaling (Ilmunik.com, 2020)**

Kawung also includes a very old design, consisting of circles that intersect each other. The Kawung Batik motif has been known in Java since the 13th century, appearing in carvings in several temples in Java, such as Prambanan and Kediri (Rizali, 2001). For many years, this part was protected only for the royal family of the Palace. Circles were sometimes filled with two or more crosses or other ornaments such as intersecting lines or dots.

Kawung batik motifs generally have two kinds of beauty: the first is visual beauty, which is a sense of beauty obtained due to the harmony and arrangement of shapes and colours through sight or five senses. Secondly, the beauty of the soul, or philosophical beauty, is obtained through the arrangement of the meanings of the symbols and embellishments that adorn a picture in accordance with the understanding it provides (Ayu, et al., 2019; Susanto, 1973).

In this paper, a Fourier Transform is applied, and it is shown that batik has fractal characteristics. This character is displayed in the fractal dimension of batik fractal characteristics. The isen process in batik is one of the factors that contributes to creating self-affinity as an important characteristic of fractals. Another test is used to test the dimensions in this method and classify batik according to pattern and region. Fractals in batik show the

complexity of traditional arts. The presence of fractals in batik forms the basis of this writing: an algorithm that will produce a new type of pattern called Fractal Batik. The fractal dimension is used as a measurement tool to make patterns. Fractal Batik is to be compared with traditional batik (Lukman, Hariadi & Achmad, 2007). The algorithm for creating Fractal Batik has been developed into software known as Batik. As software, jBatik becomes a tool for batik makers to make new patterns (Hariadi, Lukman, & Destiarmand, 2013).

In the journal, the circle, which is the most basic pattern of a picture, is discussed. Circular patterns can be formed mathematically through fractal geometry. A circular pattern applied with the fractal formula can produce a very diverse new circular pattern. The fractal method is used in circular patterns because the concept of fractals can produce similar patterns at all scales. The diversity of fractal patterns can be seen in graphics, colours, sizes, and patterns. The application of the fractal method to a circular pattern can solve the problem of the limitations of the circular motif. The resulting motifs range from simple to unique shapes. Current computer technology will help produce new and more diverse batik patterns. The existence of fractal-based circular patterns will make batik patterns more diverse and beautiful (Prastyo & Mulyana, 2014).

Archiving of kawung batik motifs can be done using turtle graphics, so storage is simpler and requires less memory. The results of kawung batik motifs raised with a turtle chart can be used as preliminary drawings before making batik by hand or with a stamp so that it is beneficial for batik productivity.

Literature Review

Arifian, Kusuma, Siswo, & Ansori (2018) discuss the development of batik motifs by exploring new patterns for batik, namely Acropora Humilis. This is a type of coral reef that is rarely found using fractal batik operations, namely batik motifs made with mathematical calculations. One of the most frequent methods used in fractal batik is the Lindenmayer system (L-System), which is a method of repetition that creates virtual plants, for example, roots, stems, branches, leaves, and flowers.

Determination of the primary coral reef model (motif) and batik ornament motif are done vertically because this follows the vertical reference of Batanghari batik fabric from Jambi. This web-based batik application is considered capable of being an application that can preserve batik motifs and create modern batik motifs in the future that can be accepted by the public (Soesanti, 2015).

In the journal Saefurrohman & Ningsih (2016), the development of guardian batik motifs with various features are mentioned, including Dewi Semboja Batik, Ilir Ilir Batik, Isuk

Afternoon Batik, Paddy and Cotton Batik, Puspowarno Arum Batik, Putri Malu Batik, Asmaranala Rimpang Batik Wahyuning Sumulur, Klaras Godong Gedang Batik and Batik Ringin Cakra Mustika. Batik motifs illustrate the journey and philosophy of the saints when developing Islamic religious propaganda in the land of Java.

Guardian batik, with all kinds of designs, is an example of a pattern designed with the use of the concept of a fractal and L-System algorithm, namely Kembang Isuk afternoon pattern with quite a deep philosophy. Datan Serik seagrass Ketaman and Datan Samun seagrass Kelangan (with meanings expressing it is not easy to despair when in a disaster, so do not be sad if lost) are to be re-designed and designed using a fractal and L-system algorithm. Fractal batik in this defining stage groups flower motifs to expand and bud into a benchmark, making Sulur more structured to be modified in a simpler form.
The journal of Marom (2017), discusses the use of the Wolframs-based programming language mathematics for the application of developing batik by using mathematical concepts, especially geometry and fractal geometry.

According to the journal of Garnadi, Guritman, Kusnanto, & Hanum (2012), research on unit lattices that form a batik pattern is discussed. There are 17 types of repetitive patterns (unit lattices) that are used to create batik patterns on a flat plane. In the study, 262 batik patterns were collected, both geometric and non-geometric. These patterns were arranged in circles, triangles, rectangles, etc. For geometric batik, the unit lattice can be determined, while for non-geometric batik, the lattice unit can be determined. Batik patterns in Indonesia can be formed with a pattern that is repeated by shifting, turning, reflecting, or sliding reflections. Each batik pattern's repetition will form a lattice. There are 5 types of lattice: rectangular, parallelogram, rhombus, square, and hexagonal.

In the journal of Dewi, Dari, & Indriani (2016), the development of Banyuwangi Oling batik using the fractal method is discuessed. The purpose of the research here is to enrich the form of the banyuwangi elephant batik. Figure 2 shows the form of the Banyuwangi elephant batik, which is commonly found. After being developed with fractals, the Banyuwangi oling elephant batik is obtained.

Figure 2. Rhinoceros-beetle (Ilmunik.com, 2020)

According to Prasetyo & Simatupang (2019), the improvement of batik motifs was discussed using the LBP Run length method and the Sine-cosine optimiser. Batik patterns have additional colour features that distinguish batik motifs. In this study, LBP mp1 and LBP rfu2 methods are used. Research on improving batik motifs has been carried out with LBP mp1 and LBP rfu2 methods. The combination of MRL from LBP and the colour features on batik produces good accuracy.

The journal of Wulandari, Purnomo, & Kamsyakawuni (2017) discusses the typical Labako batik in Jember City. The word Labako comes from the term "La Bako" which is taken from the Madurese language. Labako describes the activities of farmers growing and processing tobacco leaves. Jember Regency is one of the best tobacco producing cities in Indonesia, so the shape of tobacco leaves is the most dominant characteristic in making Labako Batako. Development of Labako batik motifs is done by producing tobacco leaf patterns using the L-System and then combining them with the dragon curve fractal geometry that has been modelled with Matlab software.

Adnyana, Kesiman, & Wahyuni (2013) make batik motifs with the application of making batik motif patterns built with the Delphi programming language. Applications are made using the fractal method, and the results are leaf motif variations. The methods used are geometry operations, negative images, image blending, thresholds, and recursion.
The journal of Setiani & Suyoto (2010), discusses the use of the Elisabeth and Prewit method, and modification of the Sobel method to detect the edges of Javanese batik patterns. Prewitt has several benefits including having a good method of handling straight lines and reducing noise. The Sobel method provides results with more noise but is quite good at detecting curve lines. The Elisabeth method combines the two methods, so the results of the Elisabeth method detect vertical and horizontal straight lines. There is reduced noise, so the results are clearer. The curve lines have better results and are clearer when colours have the same colour as the environmental pixels, the edge detection results are completely clear.

Shidi & Suyoto (2011) discuss the use of edge detection with the canny and prewit methods, which are then combined in the Thomas method. The differences in the results of the three methods are distinguished in terms of accuracy, quality of results, and clarity. Examples of batik that will be used are machete motifs, slope motifs, and lyrical udan. All three of these batiks have unique patterns.

Isen batik motif is an additional form of dots, lines, and a combination of dots and lines to decorate the basic batik forms (Kudiya, 2019; Van Roojen, 1997). Isen enriches and becomes the characteristics of each batik motif. Isen is often difficult to distinguish from basic batik motifs.

Methods

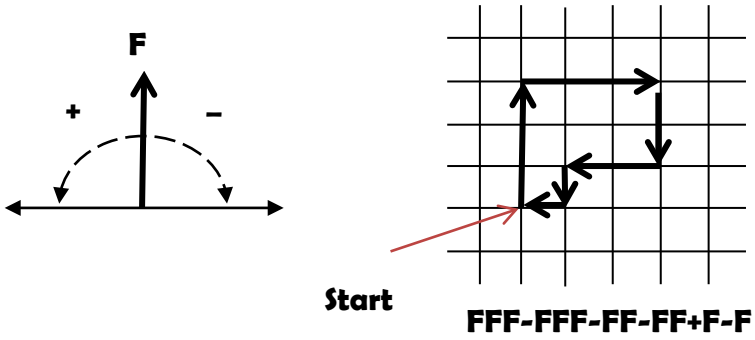
The method used in the study involved turtle graphics. Before drawing a graph turtle, the batik motif was sketched first on paper, and then the graph equation was sought. The basic idea of turtle interpretation is given in Table 1.

Table 1. Turtle graphics commands

Symbol	Interpretation	Meaning
F	Move forward and draw a line.	Proceeding one step along d. The state of the tortoise changed to (x ', y', α), with x '= x + d.cos α and y' = y + d.sin α. Draw line segments between points (x, y) and (x ', y').
f	Move forward without drawing a line.	Go one step long d without drawing a line.
+	Turn left with the angle δ.	The state of the next turtle is (x, y, α + δ). Positive orientation from a counterclockwise angle.
-	Turn right with the angle δ.	The next turtle state is (x, y, α - δ).
push	Remember the current state.	Remember the current state (position, angle, line colour).
pop	Restore the last remembered state.	Restore the last remembered state and remove it from the list of remembered states.

The state of the turtle is defined as a triplet (x, y, α) with Cartesian coordinates (x, y) representing the position of the turtle and the angle α, called the heading (head), which is interpreted as the direction the turtle faces. Given the step size and the incremental angle δ, the turtle can respond to the commands represented by symbols (Figure 3).

Figure 3. (a) Turtle interpretation of the string symbol F, +, and -. (b) Interpretation of a string: increased angle δ equals 90◦, initially the turtle faces upwards



(a) (b)

Searching the edge of batik motifs can also be done using image processing, namely edge detection using canny edge detection so that the edges of the batik motif are obtained (Ma, Li, Zhang, & Yan, 2012). In the research here, the edge detection results will be compared with the results of the turtle graphics.

Results and Discussion

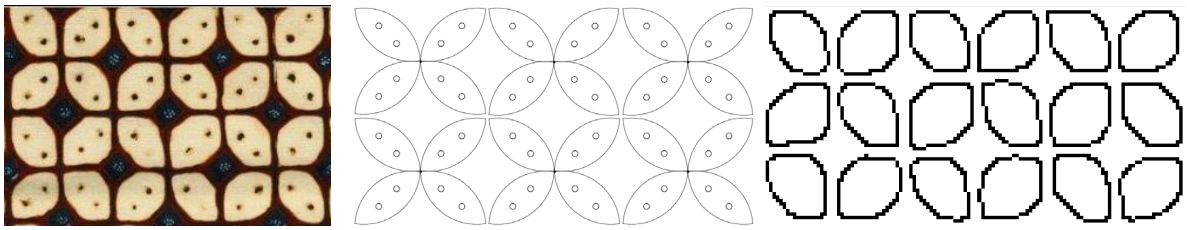
Kawung motifs are motifs that are composed of elliptical shapes and arranged lengthwise according to diagonally sloping lines to the left and right alternately (Kudiya, 2019). The elliptical shape and cross arrangement describe the structure of the universe. The centre of the crossing is a source of energy and is a miniature of the universe. This form of kawung is found on sculptures of statues in Buddhist and Hindu temples and batik motifs. This kawung motifs' use may only be by the king and the royal family. In wayang, this motif is used by Ki Lurah Semar and his children. In wayang, Semar is a commoner who has the wisdom of a god. This is why Semar, as a commoner, can use the kawung motif. Not just anyone can use this motif, only people who have more mastery and people who have the qualities of gods who are wise and prudent. Here, art plays a big role in people's lives in terms of expressing the depth of life's philosophy. This kawung motif can only be worn by people who have a high position in power or people who are considered linuwih (having advantages) (Agustin, 2014; Kusrianto, 2013).

There are a variety of motifs including kawung: Kawung Beton, Kawung Blingon, Kawung Bulan, Kawung Buntal, Kawung Branta, Kawung Bratayuda, Kawung Brendi, Kawung Brengos, Kawung Bribil, Kawung Cacah Gori, Kawung Dompol, Kawung Galar, Kawung Gamblok, Kawung Ganggong, Kawung Garuda, Kawung Gringsing, Kawung Ketunggeng, Kawung Kemiri Kopong, Kawung Kemplong, Kawung Kemplang In The White Background,

Kawung Kusumaguna, Kawung Kopi Pecah, Kawung Kempyar, Kawung Madura, Kawung Manila, Kawung Ndil, Kawung Pecah, Kawung Peksi Kreno, Kawis Picis, Kawung Plentong, Kawung Poleng, Kawung Prabu, Kawung Putri, Kawung Raja, Kawung Rante, Kawung Sawo Bludru, Kawung Sawut, Kawung Sen, Kawung Sewu, Kawung Ukel, Kawung Uter, Kawung Winarno (Kusrianto, 2013). However the names of kawung motifs can generally be grouped based on the size of the oval round shape that forms the kawung motif (Hartanti & Setiawan, 2019):

1. Kawung Picis

Figure 4. Kawung picis (a) Fabric (Ilmunik.com, 2020) (b) Turtle graphics (c) Edge detection



(a) (b) (c)

Kawung picis (the name of a small currency worth 10 cents) is a small sized arranged kawung. Table 2 is a pseudocode of turtle graphics for the Kawung picis batik with two Isen dots. Figure 4 (a) shows a photo of the Kawung picis batik motif from fabric batik, and Figure 4 (b) shows the Kawung picis batik motif from turtle graphic. Figure 4 (c) shows the Kawung batik motif from edge detection. Isen used in Kawung Picis here is in the form of two dots in each oval shape. Isen makes each Kawung motif different and beautifies the kawung motif that is produced. Isen in kawung picis with turtle graphics can be seen clearly (Figure 4 (b)), while Isen in kawung picis with edge detection cannot be detected (Figure 4 (c)).

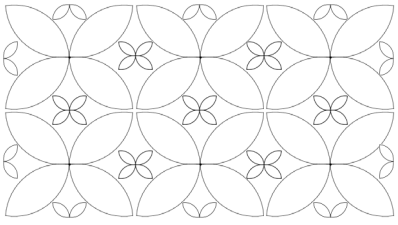
Table 2. Turtle graphics Kawung picis batik

	Pseudocode Turtle graphics Kawung picis batik
1	**procedure** A
2	**for** dir ← -1 to1 **do**
3	Push
4	angle ← dir*0.104
5	turnleft(angle)
6	**for** i ← 1 to 16 **do**
7	Forward(0.1)
8	angle ← dir*0.104
9	turnleft(angle)
10	**end for**
11	angle ← dir*7.756
12	turnleft(angle)
13	**for** i ← 1 to 16 **do**
14	Forward(0.1)
15	angle ← dir*0.104
16	turnleft(angle)
17	**end for**
18	pop
19	**end for**
20	**return** A
21	**end procedure**
22	A1 ← **procedure** A
23	A1 ← Rotate(A1, pi)
24	lingkaran ← circle(0.5)
25	lingkaran1 **:=**translate (lingkaran,x,y)
26	**plot** (A,A1,lingkaran1)

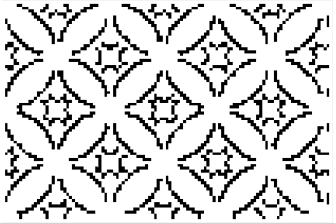
2. Kawung Bribil

Figure 5. Kawung Bribil (a) Fabric (Ilmunik.com, 2020) (b) Turtle graphics (c) Edge detection

(a)



(b)



(c)

Kawung bribil (the name of the currency is greater than half a cent's picis money) is a rather large Kawung arrangement. Table 3 is a pseudocode of turtle graphics for the Kawung bribil batik. Figure 5 (a) shows a photo of the Kawung bribil batik motif from fabric batik, and Figure 5 (b) shows the Kawung bribil batik motif from turtle graphics. Figure 5 (c) shows the Kawung bribil batik motif from edge detection. Isen used in Kawung Bribil is the same as Kawung Bribil, which is only smaller in size and placed in the middle of Kawung Bribil.

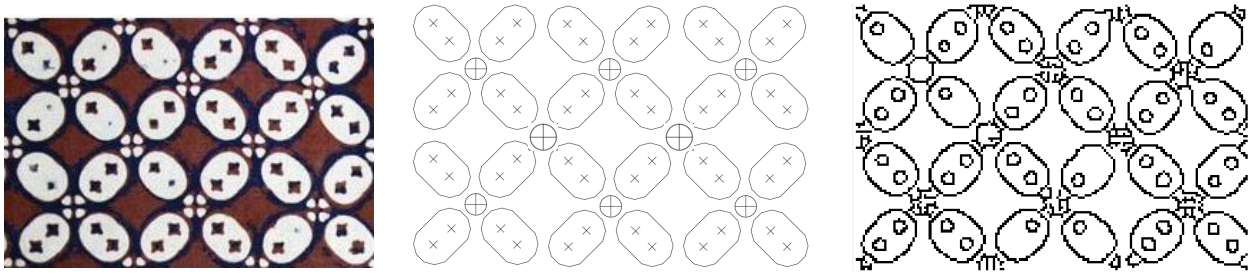
Isen in Kawung Bribil with turtle graphics can be seen clearly (Figure 5 (b)), while Isen in Kawung Bribil with edge detection is detected with a different shape from the original form (Figure 5 (c)).

Table 3. Turtle graphics Kawung bribil batik

Pseudocode Turtle graphics Kawung bribil batik	
1	**procedure** B
2	**for** dir ← -1 to1 **do**
3	push
4	angle ← dir*0.104
5	turnleft(angle)
6	**for** i ← 1 to 16 **do**
7	Forward(0.1)
8	angle ← dir*0.104
9	turnleft(angle)
10	**end for**
11	angle ← dir*7.756
12	turnleft(angle)
13	**for** i ∈ [1,16] **do**
14	Forward(0.1)
15	angle ← dir*0.104
16	turnleft(angle)
17	**end for**
18	pop
19	**end for**
20	**return** B
21	**end procedure**
22	B1 ←**procedure** B
23	B1 ← Rotate(B1, pi)
24	**plot** (B,B1)

3. Kawung Sen

Figure 6. Kawung sen (a) Fabric (Ilmunik.com, 2020) (b) Turtle graphics (c) Edge detection



(a) (b) (c)

Kawung sen is a kawung that is larger than a bribil kawung. Table 4 is the pseudocode of turtle graphics for the Kawung sen batik. Figure 6 (a) shows a photo of the Kawung sen batik motif from fabric batik, and Figure 6 (b) shows the Kawung sen batik motif from turtle graphics. Figure 6 (c) shows the Kawung sen batik motif from edge detection. The Isen used in Kawung Sen here is in the form of two cross marks on the oval shape of the Kawung Sen motif, plus a circular shape that is crossed in the middle and placed in the centre of the kawung sen.

Isen in kawung sen with turtle graphics can be seen clearly (Figure 6 (b)), while isen in kawung sen with edge detection is not entirely detected (Figure 4 (c)).

Table 4. Turtle graphics Kawung sen batik

	Pseudocode Turtle graphics Kawung sen batik
1	**procedure** C
2	angle ← 0.785
3	turnleft(angle)
4	**for** i ←1 to 3 **do**
5	Forward(0.2)
6	angle ← 0.523
7	turnleft(angle)
8	**end for**
9	Forward(0.6)
10	angle ← 0.523
11	turnleft(angle)
12	**for** i =5 **do**
13	Forward(0.2)
14	angle ← 0.523
15	turnleft(angle)
16	**end for**
17	Forward(0.6)
18	angle ← 0.523
19	turnleft(angle)
20	Forward(0.2)
21	angle ← 0.523
22	turnleft(angle)
23	Forward(0.2)
24	**return** C
25	**end procedure**
26	C1,C2,C3 ←**procedure** C
27	C1 ← Rotate(C1, pi/4)
28	C1 ←translate (C1,x,y)
29	C2 ← Rotate(C2, pi)
30	C2 ←translate (C2,x,y)
31	C3 ← Rotate(C3, pi*3/4)
32	C3 ←translate (C3,x,y)
33	**plot** (C,C1,C2,C3)
34	**Determine** cross inside kawung sen

Conclusion and Suggestions

Various kawung batik motifs have been formed with turtle graphics. Handmade and stamped batik crafters can make the results of the motif, so it is beneficial for batik crafters to make kawung batik motifs. In this paper, we present kawung picis, kawung bribil, and kawung sen. Each kawung batik motif is formed with a different turtle graphic equation. This can be seen in the pseudocode of each motif: If the shape is almost similar, then the pseudocode can be the same, but if the shape is different, then the pseudocode will also be different. The addition of isen to a motif needs to be done with another turtle graphic equation. As a comparison, canny edge detection can be used to obtain kawung batik motifs. The results of canny edge detection, especially for some, may not be detected or be partially detected. With the turtle graph, all batik isen-isen can be described. Future studies of turtle graphics are expected to be applied to other motifs.

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REFERENCES

Adnyana, I. P. W., Kesiman, M. W. A., & Wahyuni, D. S. (2013). Pengembangan Aplikasi Pembuatan Pola Motif Batik Dengan Menggunakan Pengolahan Citra Digital. *Jurnal Nasional Pendidikan Teknik Informatika (JANAPATI)*, *1*(2), 164–172. https://doi.org/10.23887/janapati.v2i2.9793

Agustin, A. (2014). Sejarah Batik Dan Motif Batik Di Indonesia. In *Seminar Nasional Riset Inovatif*, *2*.

Arifian, D., Kusuma, P. D., Siswo, A., & Ansori, R. (2018). Pengembangan Motif Karang Jenis Acropora Humilis Pada Aplikasi Batik Berbasis Web Dengan Metode Lindenmayer System, Web Base Application for Batik Pattern Generation of Acropora Humilis Coral Motif with Lindenmayer System Method. In *e-Proceeding of Engineering*, *5*, 2403–2408.

Ayu, P. N., Pramesti, N. A., Pamadhi, H., & Garbo, A. (2019). Local Wisdom Values in Kawung Batik and Its Relevance to Moral Education. In *International Conference on Art and Arts Education (ICAAE 2018)*. Atlantis Press. https://doi.org/10.2991/icaae-18.2019.34

Bram. (2017). *Batik Kawung - Motif Untuk Orang Yang Berhati Bersih Asal-Usul Batik Kawung*. Retrieved from www.pemoeda.co.id/blog/batik-kawung

Dewi, R. A. M., Dari, R. R., & Indriani, E. (2016). Geometri Fraktal Untuk Re-Desain Motif Batik Gajah Oling Banyuwangi. *Aksioma*, *5*(2)., 222–230.

Garnadi, A. D., Guritman, S., Kusnanto, A., & Hanum, F. (2012). Survey Pola Grup Kristalogi Bidang Ragam Batik Tradisional. *Journal of Mathematics and Its Applications*, *11*(2), 1. https://doi.org/10.29244/jmap.11.2.1-10

Hapsari, W., & Haryono, N. A. (2018). Pembuatan Sistem Desain Batik Dengan Komputasi Matematis. In *Seminar Nasional Teknologi Informasi dan Komunikasi (SEMNASTIK)*, *1*(1), 521-527.

Hariadi, Y., Lukman, M., & Destiarmand, A. H. (2013). Batik Fractal : actal : Marriage of Art and Science. *ITB Journal Vis. Art & Des*, *4*(1), 84–93. https://doi.org/10.5614/itbj.vad.2013.4.1.9

Hartanti, G., & Setiawan, B. (2019). Pendokumentasian Aplikasi Ragam Hias Batik Jawa Tengah Motif Kawung, Sebagai Upaya Konservasi Budaya Bangsa Khususnya Pada Perancangan Interior. *Aksen*, *3*(2), 25–37.

Ilmunik.com. (2020). Motif Batik Kawung , Sejarah , Makna , dan Filosofi (Terlengkap) Sejarah Motif Batik Kawung Berasal Dari Kerajaan Mataram. Retrieved from https://ilmunik.com/motif-batik-kawung/

Kudiya, K. (2019). *Kreativitas Dalam Desain Bantik* (I). Bandung: ITB Press.

Kusrianto, A. (2013). *Batik - Filosofi, Motif & Kegunaan* (1st ed.). Yogyakarta: Andi Offset.

Lukman, M., Hariadi, Y., & Achmad, H. D. (2007). Batik Fractal: Traditional Art to Modern Complexity. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.583.7813&rep=rep1&type=pdf

Ma, X., Li, B., Zhang, Y., & Yan, M. (2012). The Canny edge detection and its improvement. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *7530*, 50–58. https://doi.org/10.1007/978-3-642-33478-8_7

Marom, S. (2017). Application of Fractal Concept in Material Batik Development Based on Wolframs Mathematica. *ZERO: Jurnal Sains, Matematika Dan Terapan*, *1*(2), 49–61. https://doi.org/10.30829/zero.v1i2.1461

Parmono, K. (2013). Nilai Kearifan Lokal Dalam Batik Tradisional Kawung. *Jurnal Filsafat*, *23*(2), 134-146.

Prasetyo, H., & Simatupang, J. W. (2019). Batik Image Retrieval Using Maximum Run Length LBP and Sine-Cosine Optimizer. *ICSECC 2019 - International Conference on Sustainable Engineering and Creative Computing: New Idea, New Innovation, Proceedings*, 265–269. https://doi.org/10.1109/ICSECC.2019.8907190

Prastyo, A., & Mulyana, T. M. S. (2014). Aplikasi Pola Batik Menggunakan Metode Fraktal dan Algoritma Lingkaran 8 Way Simetris. *Jurnal Teknologi Informasi*, *10*(2), 1–9.

Rizali, N. (2001). Tinjauan Filosofis dan Semiotik Batik Kawung. *Wacana Seni Rupa*, *2*(1).

Rosanto, A. (2009). Kajian Batik Motif Kawung Dan Parang Dengan Pendekatan Estetika Seni Nusantara. *Brikolase: Jurnal Kajian Teori, Praktik dan Wacana Seni Budaya Rupa*, *1*(2)

Saefurrohman, & Ningsih, D. H. U. (2016). Desain Motif Batik Dengan Metode Fraktal Dan Algoritma L-System untuk Membangun Pustaka Batik Wali. *Dinamik*, *21*(1), 42–51.

Sarwono. (2005). Motif Kawung sebagai Simbolisme Busana Para Abdi dalam Wayang Kulit Purwa Gaya Surakarta. *Harmonia Jurnal Pengetahuan Dan Pemikiran Seni*, *VI*(2), 1–14.

Setiani, E. D., & Suyoto, S. (2010). New Edge Detection Method Using Elisabeth Method: Case Study Javanese Batiks. *Jurnal Buana Informatika*, *1*(1), 47–56. https://doi.org/10.24002/jbi.v1i1.289

Shidi, T. A. P., & Suyoto. (2011). New Edge Detection Method for Indonesian Batik. *Jurnal Buana Info*, *2*(1), 55–62.

Soesanti, I. (2015). Design and development of Web-Based Information System for The Batik Industry. *IPTEK Journal of Proceedings Series*, *1*(1). https://doi.org/10.12962/j23546026.y2014i1.388

Susanto, S. S. (1973). *Seni Kerajinan Batik Indonesia*. Balai Penelitian Batik dan Kerajinan, Lembaga Penelitian dan Pendidikan Industri, Departemen Perindustrian RI.

Van Roojen, P. (1997). *Batik Design*. Shambhala Publications.

Wulandari, E. Y., Purnomo, K. D., & Kamsyakawuni, A. (2017). Pengembangan Desain Batik Labako Dengan Menggabungkan Geometri Fraktal Kurva Naga dan Corak Daun Tembakau (Development of Labako Batik Design with Fractal Geometry Dragon Curve and Tobacco Leaf Motif Combonation). *Jurnal Ilmu Dasar*, *18*(2), 125–132. https://doi.org/10.19184/jid.v18i2.5650

Yodha, J. W., & Kurniawan, A. W. (2014). Pengenalan Motif Batik Menggunakan Deteksi Tepi Canny dan K-Nearest Neighbor. *Techno. com*, *13*(4), 251-262.