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Batik's Pattern Recognition and Generation: Review and Challenges

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Abstrak

Batik adalah salah satu warisan budaya yang diakui oleh UNESCO. Sistem cerdas datang sebagai salah satu solusi untuk mendukung program pelestarian dari warisan budaya ini. Studi ini mengeksplorasi capaian saat ini pada aplikasi kecerdasan tiruan pada gambar batik. Penelitian ini memberikan investigasi sistematik dan mempresentasikan progres saat ini dan topik-topik hangat pada bidang pengenalan dan pembangkitan untuk gambar Batik. Penelitian ini juga merangkum beberapa data Batik beserta state-of-the-art dari data tersebut dan memproyeksikan beberapa topik yang dapat dilakukan pada bagian diskusi.

Kata kunci: *kecerdasan tiruan, pengenalan batik, pembangkitan batik, pengolahan citra*

Abstract

Batik is one of cultural heritage acknowledged by UNESCO. Intelligence system comes as one of solution to take parts on preservation programs of this heritage. This study explores the current state of the art in application of artificial intelligence on Batik images. This research provides a systematic investigation and present the current progress and hot issues in recognition and generation area for Batik images. Furthermore, this research also presents several Batik data sets and their state of the art and projecting several future works in the discussion.

Keywords: *artificial intelligence, batik recognition, batik generation, image processing*

1. Introduction

Batik is an Indonesian cultural heritage which philosophically possesses visceral meaning and high value. United Nations Educational Scientific and Culture Organization (UNESCO) has also acknowledged it as one of the worlds cultural heritages [1]. Batik can be found in various Indonesia's regions, but the pattern might be different. The Batik's pattern might be different in various Indonesia's regions because of each pattern representing tradition and culture in such a region.

Generally, Batik has two types of patterns [2]. The first pattern is geometric. The examples of this pattern are Ceplok, Banji, Parang, Kawung, and Mega Mendung. The second pattern is a non-geometric pattern like Semen, Cuwiri, Lunglungan, and Buketan. The craftsmen usually arrange such kind of pattern frequently on the material [3]. The variety of batik patterns becomes challenging for the Indonesian government to preserve this cultural heritage. However, the details of information are harder to collect because only particular people learn it.

The information communication technologies bring new options to provide and share cultural heritage, and these options are suitable as preservation tools. Cantoni et al. [4] mention five areas where the information communication technologies useful in cultural heritage, such as easy access, better experience, connecting locals and visitor, dis-intermediate to improve business activities, and support the training and education activities. To overcome the preservation issue, particularly Batik, worldwide researchers in computer sciences try to address it by proposing an automatic system that provides details of specific batik patterns.

Beside, various research also have been tried to create a various kind of system and using artificial intelligence [5]–[7]

In this study, we summarise previous approaches which have been proposed to analyse batik pattern. We collect var- ious literature from 2015 to present from various sources. Then, we arrange them into several groups by approach similarity. In advance, this paper has several contributions which can be divided into four parts as follows.

1. Categorise all approach which has been done to analyse the pattern of Batik.
2. Summarise all batik dataset which can be accessed publicly. We also provide the challenge for each dataset and current state of the art.
3. We are presenting the current benchmark method for each Batik's dataset.
4. Present future research direction related to Batik

The rest of this study is written as follows. Section II analyses various batik pattern recognition approach. Section III presents the batik pattern synthesis method. Section IV provides several batik datasets which publicly available and its state of the art. Section V concludes our findings with future directions.

2. Research Method

This review is following the systematic review guidelines used in [8]. Firstly, we gather the literatures from various sources such as IEEE Explorer, ScienceDirect, and ACM Digital Library. Since the literatures are limited due to a specific object, we further explored secondary indexer through Google Scholar and Researchgate. Then the collected literatures are filtered by their quality in terms of their quality. Secondly, we identified the problem and mapping the proposed method for each refined literature. Thirdly, we analyze the open problem and providing the future direction for the future research.

After collecting and refining the gathered literature, we got 22 papers. Then, we create a state-of-the-art matrix and found that there are two main tasks related to Batik, such as recognizing the Batik's motif and synthesizing Batik's pattern, which will be further explained in section 3 and 4.

3. Batik's Pattern Recognition Approach

3.1. Image Retrieval-based Approach

Table 1 present several research which is developed based on the image retrieval-based approach. Majorly, the texture feature-based was preferred here. Fahmi et al. [9] combining four methods that produce a high data dimension, reducing and filtering those features using sequential forward floating selection [10] or principal component analysis [11] through a performance comparison. They report that principal component analysis has better precision than sequential forward floating selection but slower in the retrieval execution time. However, the difference is not significant. Similar approaches use in [12], [13] . Nurhaida et al. [12] compare several feature combinations experimentally, like Gabor features, log-Gabor features, grey level co-occurrence matrices, and local binary pattern features. The results show that all combination provide high precisions but low recalls. Moreover, Prasetyo et al. [13] combine ordered dither block truncation coding with a particle swarm optimization to find the optimal value for similarity weighting constants to enhance the retrieval performance. In ordered dither block truncation coding, they extract colour feature and texture feature.

The method for matching the test image with the database also affects retrieval performance. Prasetyo et al. [13] demonstrate the trend for $L1$, $L2$, $x2$, and canberra distance in precision and recall value. From the four scenarios, the canberra distance outperformed other methods in three scenarios where the block sizes are 4×4, 8×8, and 32×32. In block size 16 × 16, the canberra distance is in the second position. In advance, Prasetyo et al. [13] optimize the canberra distance performance using particle swarm optimization. The particle swarm optimization is used to optimize the value of $\alpha1$, $\alpha2$, and $\alpha3$. The particle swarm optimization is able to improve the performance of canberra distance 0.5% of accuracy.

Table 1 Content based image retrieval-based approach

Authors	Feature extraction method	Retrieval method
[9]	Features: Gabor filter, log-gabor filter, GLCM, LBP. Feature selection is done by using SFFS and PCA	euclidean distance
[33]	Scaled invariant feature transform with hough transform	euclidean distance
[12]	Feature fusion (Gabor, Log-gabor, GLCM, LBP)	euclidean distance
[13]	Ordered dither block tuncation coding (ODBTC)	L1, L2, X2, and modified canberra distance

Table 2 Batik's pattern classification using various feature extractor and classification methods

Authors	Feature extraction method	Classification
[2]	Various pretrained-convolutional neural networks	Softmax
[14]	Fast Discrete Curvelet Transform + hue saturation value	K-Nearest Neighbour
[15]	Gabor filter, log Gabor filter, gray level co-occurence matrix, and LBP followed by a principal component analysis	deep neural network
[16]	Gray level co-occurence matrix, deep belief network, convolutional neural network	SVM, Softmax, Fully-connected layers+Softmax
[20]	Pretrained VGG-16	Random forest and SVM
[34]	Gray level co-occurence matrix + statistical color channel RGB	backprogagation neural network
[35]	Gray level co-occurence matrix + shape features	three layers neural network
[36]	Gray level co-occurence matrix and shape features + feature selection using information gain	three layers neural network
[37]	Gray level co-occurence matrix + SURF	K-Nearest Neighbour
[38]	IncRes	Fully-connected layers + Softmax
[39]	Geometric invariant moment	K-Nearest Neighbour
[32]	Pretrained VGG-16 and VGG-19	Fully-conencted layers + Softmax
[40]	Gray level co-occurence matrix	three layers neural network backpropagation
[28]	Pretrained VGG-16	Various classifiers
[28]	Multi-texton co-occurrence descriptor	SVM

3.2. Classification-based Approach

This method can be divided into two parts, as shown in Table 2. The first part is the feature extraction process. The purpose of this process is extracting a unique key representation from the given data to improve the classification performance in the second part.

A texture-based approach dominates the feature extraction method. Suciati et al. [14] combine a fast discrete curvelet transform and the hue saturation value then the k-nearest neighbour placed to classify the features. Moreover, the statistical features from the grey level co-occurrence matrix are dominating the texture-based method. The statistical fea tures were computed from the grey level co-occurrence matrix, for example, contrast, correlation, energy, homogeneity, and entropy [15]. Nurhaida et al. [15] combined those features with feature reduction using principal component analysis and followed by a deep neural network. They also show how the batch normalization takes effect on boosting the deep neural network performance. This approach shows a significant upgrade from the standard deep neural network.

Deep learning methods also take parts in recognizing Batik's patterns. Handhayani et al. [16] found that VGG16 [17] and ResNet [18] were underperformed. The deep of the network is not continuously increase the accuracy of such a model on a particular problem. A simple

Table 3 Generation and synthesize Batik's pattern method

Authors	Synthesize approach
[25]	GAN with captions
[26]	deep convolutional generative adversarial networks with modification
[27]	BatikGAN, BatikGAN with style, BatikGAN with style and local features

Table 4 Publicly available of Batik dataset. Note: NoC refers to number of classes

No	Dataset name	Class number	Total images
1	Gultom dataset	5	2.092
2	Minarno dataset	50	300

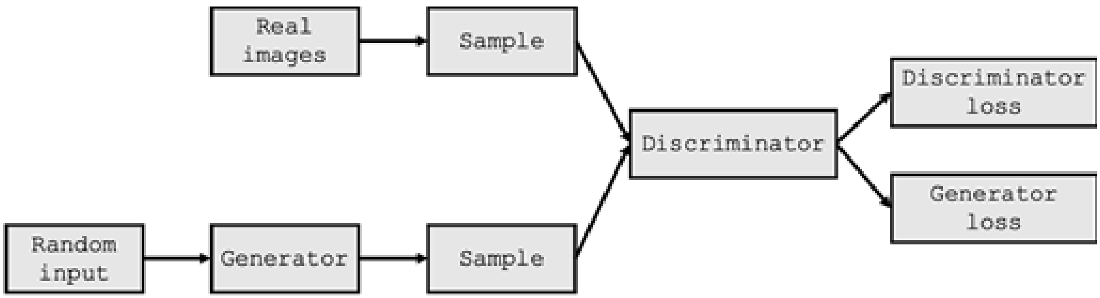

Figure 1 Generative adversarial networks architecture proposed in [26], [27]

convolutional neural network consisting of three convolution layers can place in the third position of accuracy in [16].

Moreover, in contrast with Handhayani results in [16], Rasyidi et al. [2] recently show that pre-trained networks can be used to recognise the ornament on Batik images. Rasyidi et al. [2] compared the accuracy, precision, and recall of AlexNet and various type of DenseNet, ResNet, SqueezeNet, and VGG. Gultom [19] and Arsa [20] also produce similar results where the pre-trained networks have outstanding performance when used on other domains.

4. Automatic Batik's Pattern Generation and Synthesis

Batik pattern synthesis has been a new challenge in processing batik images. This approach enabling the fusion of several ornaments or generate patterns with different style using artificial intelligence. As we can see in Table 3, all of the methods were built based on generative adversarial networks. This method has known its performance for generating images [21]–[27].

Figure 1 shows the general architecture used in [25]–[27]. Amalia et al. [25] and Abdurrahman et al. [26] use a standard generative adversarial network, as shown in Figure 1a. The difference is the construction of generator and discriminator. Then, Chu et al. [27] propose a different design of the generation method. Their method receives two patches of batik patterns as input to synthesis a new batik image.

BatikGAN [27] shows better performance compared with [25], [26]. The generated images present more details in the pattern where Amalia's approach [25] and Abdurrahman's approach [26] have more unstructured patterns if we scale the image. The three designed discriminators, such as pretrained VGG-19, global discriminator, and local discrimina tor, improve the quality of synthesis because each discriminator focuses on one task. For example, the global discriminator checks small local areas, and local discriminator determines the generated images' details.

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Table 5 Results of the previous research which was used Minarno dataset

Authors	Method	Performance
[28]	Multi texton co-occurence descriptor	acc: 100%
[20]	pretrained VGG16 + radom forest	acc: 97.50 +- 2.32%
[29]	Multi texton histogram and probabilistic neural network	acc: 92%
[30]	Multi texton histogram + k-nearest neighbours	acc: 82%
[31]	Multi structure co-occurence descriptor	avg precision: 81.47%

Table 6 Gultom dataset state of the art

Authors	Method	Accuracy
[32]	pretrained VGG19	89+-2.8%
[19]	pretrained VGG16	89+-7%
[15]	deep neural networks	85.57%

5. Batik Dataset and State of The Art

Previous research mostly built their dataset by crawling Batik images from search engines, for example, Google. We found that only two datasets are published freely. Table 4 shows some details of those datasets. Those datasets are varied in the number of classes and the total number of images. Gultom dataset provides more images per classes. The highest class number is provided in Minarno dataset with six images per class.

Table 5 shows the progress performance on developing classification method for Minarno dataset. The table presents that the Minarno dataset challenges have been solved since the current state of the art already on maximum performance [28]. Arsa et al. [20] use pre-trained VGG16 here, combined with random forest and the result still competitive. For this pre-trained network, we replace the Random Forest with Logistic Regression and produce 100% of accuracy consistently when the experiment is repeated.

Table 6 provides the current state of the art of Gultom dataset. Agastya et al. [32] approaches are the current best method. Even the accuracy is the same as Gultom [19], the standard deviation indicates that Agastya method [32] is stabler than Gultom method [19]. Moreover, a non-convolutional deep neural network can compete here, as shown by Nurhaida et al. [15] by incorporating the batch normalization process.

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6. Conclusion

Various approaches have been applied to analyze Batik image using hand-crafted features or learned features like neural networks. The recognition task is still an open problem in Batik classification because tons of motifs are not yet compiled as a dataset. The batik motif generation is attractive because it is rarely done and in the early development of Batik patterns generation. This topic may enrich the Batik motif and can be used to learn unidentified pattern. The application of the batik motif generation and recognition through mobile devices can also be developed as an effort to preserve batik as a cultural heritage that is spread throughout Indonesia.

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References

[1] UNESCO, “Indonesian batik,” *https://ich.unesco.org/en/RL/indonesian-batik-00170*.
[2] M. A. Rasyidi and T. Bariyah, “Batik pattern recognition using convolutional neural network,” *Bulletin of Electrical Engineering and Informatics*, vol. 9, no. 4, pp. 1430–1437, Aug. 2020, doi: 10.11591/eei.v9i4.2385.
[3] A.HAAKE, “The Role of Symmetry in Javanese Batik Patterns,” *International Series in Modern Applied Mathematics and Computer Science*, vol. 17, pp. 815–826, 1989.
[4] L. Cantoni, S. de Ascaniis, and M. Gravari-Barbas, “Heritage and Sustainable Tourism,” *The Role and Challenge of Information and Communication Technologies*, 2018.
[5] D. A. Savita, I. K. G. D. Putra, and N. K. D. Rusjayanthi, “Public Sentiment Analysis of Online Transportation in Indonesia through Social Media Using Google Machine Learning,” *JURNAL ILMIAH MERPATI*, vol. 9, no. 2, pp. 153–164, 2021.
[6] I. P. Y. P. Yasa, I. K. G. D. Putra, and D. M. S. Arsa, “Augmented Reality Application with Real Object Marker of Tanah Lot Temple,” *JURNAL ILMIAH MERPATI*, vol. 9, no. 1, pp. 46–57, 2021.
[7] A. A. Priyangka and I. M. S. Kumara, “ Classification Of Rice Plant Diseases Using the Convolutional Neural Network Method,” *Lontar Komputer : Jurnal Ilmiah Teknologi Informasi*, vol. 12, no. 2, pp. 123–129, 2021, doi: 10.24843/LKJITI.2021.v12.i02.p06.
[8] I. P. A. Dharmaadi, D. Made, and S. Arsa, “Studi Pustaka Sistem Pemantauan Jaringan Distribusi Air Publik berbasis Internet of Things (IoT),” *JURNAL ILMIAH MERPATI*, vol. 8, no. 1, pp. 54–60, 2020.
[9] H. Fahmi, R. A. M. Zen, H. R. Sanabila, I. Nurhaida, and A. M. Arymurthy, “Feature selection and reduction for batik image retrieval,” in *ACM International Conference Proceeding Series*, Dec. 2016, pp. 47–52. doi: 10.1145/3033288.3033327.
[10] P. Pudil, J. Novovičová, and J. Kittler, “Floating search methods in feature selection,” *Pattern Recognit Lett*, vol. 15, no. 11, pp. 1119–1125, 1994.
[11] H. Abdi and L. J. Williams, “Principal component analysis,” *Wiley interdisciplinary reviews: computational statistics*, vol. 2, no. 4, pp. 433–459, 2010.
[12] I. Nurhaida, H. Wei, R. A. M. Zen, R. Manurung, and A. M. Arymurthy, “Texture fusion for batik motif retrieval system,” *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 6, no. 6, pp. 3174–3187, 2016.
[13] H. Prasetyo, W. Wiranto, W. Winarno, U. Salamah, and B. Harjito, “Batik image retrieval using ODBTC feature and particle swarm optimization,” *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, vol. 10, no. 2–4, pp. 71–74, 2018.
[14] N. Suciati, A. Kridanto, M. F. Naufal, M. Machmud, and A. Y. Wicaksono, “Fast discrete curvelet transform and HSV color features for batik image clansificotlon,” in *2015 International Conference on Information & Communication Technology and Systems (ICTS)*, 2015, pp. 99–104.
[15] I. Nurhaida, V. Ayumi, D. Fitrianah, R. A. M. Zen, H. Noprisson, and H. Wei, “Implementation of deep neural networks (DNN) with batch normalization for batik pattern recognition.,” *International Journal of Electrical & Computer Engineering (2088-8708)*, vol. 10, 2020.
[16] T. Handhayani, J. Hendryli, and L. Hiryanto, “Comparison of shallow and deep learning models for classification of Lasem batik patterns,” in *2017 1st International Conference on Informatics and Computational Sciences (ICICoS)*, 2017, pp. 11–16.
[17] K. Simonyan and A. Zisserman, “Very deep convolutional networks for large-scale image recognition,” *arXiv preprint arXiv:1409.1556*, 2014.
[18] K. He, X. Zhang, S. Ren, and J. Sun, “Deep residual learning for image recognition,” in *Proceedings of the IEEE conference on computer vision and pattern recognition*, 2016, pp. 770–778.
[19] Y. Gultom, A. M. Arymurthy, and R. J. Masikome, “Batik classification using deep convolutional network transfer learning,” *Jurnal Ilmu Komputer dan Informasi*, vol. 11, no. 2, pp. 59–66, 2018.

[20] D. M. S. Arsa and A. A. N. H. Susila, "VGG16 in Batik Classification based on Random Forest," in *2019 International Conference on Information Management and Technology (ICIMTech)*, 2019, vol. 1, pp. 295–299.
[21] I. Goodfellow *et al.*, "Generative adversarial nets," in *Advances in neural information processing systems*, 2014, pp. 2672–2680.
[22] A. Radford, L. Metz, and S. Chintala, "Unsupervised Representation Learning with Deep Convolutional Generative Adversarial Networks," in *4th International Conference on Learning Representations, ICLR 2016, San Juan, Puerto Rico, May 2-4, 2016, Conference Track Proceedings*, 2016. [Online]. Available: http://arxiv.org/abs/1511.06434
[23] Q. Cheng and X. Gu, "Cross-modal Feature Alignment based Hybrid Attentional Generative Adversarial Networks for Text-to-image Synthesis," *Digital Signal Processing*, p. 102866, 2020.
[24] Y. Chen *et al.*, "Person Image Synthesis through Siamese Generative Adversarial Network," *Neurocomputing*, 2020.
[25] A. N. Amalia, A. F. Huda, D. R. Ramdania, and M. Irfan, "Making a Batik Dataset for Text to Image Synthesis Using Generative Adversarial Networks," in *2019 IEEE 5th International Conference on Wireless and Telematics (ICWT)*, 2019, pp. 1–7.
[26] M. Abdurrahman, N. H. Shabrina, and D. K. Halim, "Generative Adversarial Network Implementation for Batik Motif Synthesis," in *2019 5th International Conference on New Media Studies (CONMEDIA)*, 2019, pp. 63–67.
[27] W.-T. Chu and L.-Y. Ko, "BatikGAN: A Generative Adversarial Network for Batik Creation," in *Proceedings of the 2020 Joint Workshop on Multimedia Artworks Analysis and Attractiveness Computing in Multimedia*, 2020, pp. 13–18.
[28] A. E. Minarno, Y. Azhar, F. D. S. Sumadi, and Y. Munarko, "A Robust Batik Image Classification using Multi Texton Co-Occurrence Descriptor and Support Vector Machine," in *2020 3rd International Conference on Intelligent Autonomous Systems (ICoIAS)*, 2020, pp. 51–55.
[29] A. E. Minarno, Y. Munarko, A. Kurniawardhani, and F. Bimantoro, "Classification of Texture Using Multi Texton Histogram and Probabilistic Neural Network," in *IOP Conf. Ser. Mater. Sci. Eng*, 2016, vol. 105, no. 1, p. 12022.
[30] A. E. Minarno, A. S. Maulani, A. Kurniawardhani, F. Bimantoro, and N. Suciati, "Comparison of methods for batik classification using multi texton histogram," *Telkomnika*, vol. 16, no. 3, pp. 1358–1366, 2018.
[31] A. E. Minarno, A. Kurniawardhani, and F. Bimantoro, "Image retrieval based on multi structure co-occurrence descriptor," *Telkomnika*, vol. 14, no. 3, pp. 1175–1182, 2016.
[32] I. M. A. Agastya and A. Setyanto, "Classification of Indonesian Batik Using Deep Learning Techniques and Data Augmentation," in *2018 3rd International Conference on Information Technology, Information System and Electrical Engineering (ICITISEE)*, 2018, pp. 27–31.
[33] I. Nurhaida, A. Noviyanto, R. Manurung, and A. M. Arymurthy, "Automatic Indonesian's batik pattern recognition using SIFT approach," *Procedia Computer Science*, vol. 59, no. 5, pp. 567–576, 2015.
[34] C. S. K. Aditya, M. Hani'ah, R. R. Bintana, and N. Suciati, "Batik classification using neural network with gray level co-occurence matrix and statistical color feature extraction," in *2015 International Conference on Information & Communication Technology and Systems (ICTS)*, 2015, pp. 163–168.
[35] A. A. Kasim, R. Wardoyo, and A. Harjoko, "Batik classification with artificial neural network based on texture-shape feature of main ornament," *International Journal of Intelligent Systems and Applications*, vol. 11, no. 6, p. 55, 2017.
[36] A. A. Kasim, R. Wardoyo, and A. Harjoko, "The selection feature for batik motif classification with information gain value," in *International Conference on Soft Computing in Data Science*, 2017, pp. 106–115.
[37] F. U. Karimah and A. Harjoko, "Classification of batik kain besurek image using speed up robust features (SURF) and gray level co-occurrence matrix (GLCM)," in *International Conference on Soft Computing in Data Science*, 2017, pp. 81–91.

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[38] A. Y. Wicaksono, N. Suciati, C. Fatichah, K. Uchimura, and G. Koutaki, “Modified convolutional neural network architecture for batik motif image classification,” *IPTEK Journal of Science*, vol. 2, no. 2, 2017.

[39] R. E. Caraka, T. W. Cenggoro, B. Pardamean, and others, “Batik parang rusak detection using geometric invariant moment,” in *2018 Indonesian Association for Pattern Recognition International Conference (INAPR)*, 2018, pp. 71–74.

[40] J. Kusanti and A. Suprapto, “Combination of Otsu and Canny Method to Identify the Characteristics of Solo Batik as Surakarta Traditional Batik,” in *2019 2nd International Conference of Computer and Informatics Engineering (IC2IE)*, 2019, pp. 63–68.