Implementation of Discrete Wavelet Transform and Directed Acyclic Graph SVM for Batik Pattern Recognition

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Abstract

Batik as a heritage of the ancestors of the Indonesian nation, certainly needs to be preserved so that it continues to be recognized from generation to generation, one of which is by introducing the diversity of its patterns. Efforts to introduce batik patterns can be made, one of which is by implementing technology that can recognize batik patterns automatically, based on batik patterns, namely pattern recognition technology. This study aims to optimize batik pattern recognition using the discrete wavelet transform (DWT) and directed acyclic graph SVM (DAGSVM) methods. The stages start from preprocessing, feature extraction, and classification. The study used 310 batik images of 7 different patterns and divided them into 240 images for training data and 70 for testing data. The DWT method is used in the feature extraction stage, while DAG SVM is used in the classification stage. The study was conducted by comparing the accuracy between standard DAG SVM and DAG SVM that has been optimized with DWT and the results of the accuracy test proved that adding the DWT method with DAG SVM can increase accuracy by 3%.

Keywords*: batik, discrete wavelet transform, directed acyclic graph svm*

Abstrak

Batik sebagai warisan leluhur bangsa Indonesia, tentunya perlu dilestarikan agar terus dikenal dari generasi ke generasi, salah satunya dengan mengenalkan keberagaman coraknya. Upaya mengenalkan corak batik dapat dilakukan salah satunya dengan mengimplementasikan teknologi yang dapat mengenali corak batik secara otomatis, berbasis corak batik yaitu teknologi pengenalan pola. Penelitian ini bertujuan untuk mengoptimasi pengenalan pola batik menggunakan metode discrete wavelet transform (DWT) dan directed acyclic graph SVM (DAGSVM). Tahapannya dimulai dari preprocessing, ekstraksi ciri, dan klasifikasi. Penelitian ini menggunakan 310 citra batik dari 7 corak yang berbeda dan membaginya menjadi 240 citra untuk data latih dan 70 citra untuk data uji. Metode DWT digunakan pada tahap ekstraksi ciri, sedangkan DAG SVM digunakan pada tahap klasifikasi. Penelitian dilakukan dengan membandingkan akurasi antara DAG SVM standar dengan DAG SVM yang telah dioptimasi dengan DWT dan hasil uji akurasi membuktikan bahwa penambahan metode DWT dengan DAG SVM dapat meningkatkan akurasi sebesar 3%.

Keywords*: batik, discrete wavelet transform, directed acyclic graph svm*

1. INTRODUCTION

Batik is an ancestral heritage of the Indonesian nation that has characteristics and uniqueness that distinguishes the Indonesian nation from other nations, in 2009 batik Currently batik reached the peak of its popularity and has been designated as an intangible cultural heritage by the United National Educational, Science, and Cultural Organization (UNESCO) [1][2]. In general, traditional batik patterns are divided into two, namely keraton and pesisir. Batik keraton is an art that developed in the Yogyakarta Palace and Solo Palace, where the batik patterns included in this batik keraton represent philosophy based on spiritual discipline [3]. Batik pesisir is a batik art that grew in the northern region of Java. The development of this batik pesisir does not follow the pattern rules of batik keraton. Batik pesisir patterns are influenced by the culture of immigrants from the Netherlands, China, Arabia, and India [3].

Both batik keraton and batik pesisir have two main batik patterns, namely: geometric and non-geometric. Geometric batik patterns depict more symmetry and repetition of horizontal, vertical, and diagonal directions that form angles between shapes, while non-geometric batik patterns do not depict such symmetrical patterns [3]. Some geometric patterns that are often used include: kawung, banji, pilin, ceplok, parang, lumpur, and nitik. And for nongeometric patterns that are often used include: lung lungan, semen, pagersari, and taplak meja. The diverse patterns of this batik need to be preserved, and one effort to preserve this diversity is by maintaining the special characteristics of the batik pattern and continuing to introduce it to the next generation so that the diversity of batik motifs which are part of Indonesia's cultural heritage will continue to be recognized from generation to generation[3].

Efforts to introduce batik patterns can be made by implementing technology that is able to recognize batik patterns automatically based on batik patterns, namely pattern recognition technology. The stages carried out in the pattern recognition process are mostly through the preprocessing, feature extraction, and classification stages. Success in classification is very dependent on the success of the feature extraction process [3]. Wavelet transform is a feature extraction method that adopts the Fourier Transform and Short-Time Fourier Transform (STFT) methods. This wavelet transform method performs feature extraction by decomposing the vector space into nested vector spaces with different resolutions. This method is an ideal tool for signal analysis and processing. The wavelet transform has been successfully applied in various studies, including in fields such as image processing, signal analysis, computer graphics, numerical analysis, etc. [4].

Directed Acyclic Graph SVM or DAG SVM is a new algorithm for class classification. For a problem of N classes, this DAG SVM builds N(N-1)/2 classifiers for each pair of classes. Based on the decision function of the support vector machine, a more efficient data structure is used to express decision nodes in the graph, and an improved algorithm is used to find the class of each test sample [5]. This new approach improves some of the weaknesses of Decision Directed Acyclic Graph (DDAG) caused by its node structure and order, and makes decisions faster and more accurate, especially for a large number of classes. DAG SVM has been tested in various classification problems, Shyam [6] used DAG SVM to classify epilepsy disease based on EEG signals, which focused on distinguishing focal and non-focal EEG signals in this study. It was proven that DAGSVM has good accuracy. However, there needs to be an improvement in the feature extraction method so that in the classification stage, the accuracy of the DAG SVM method can be improved.

So it is necessary to optimize the Directed Acyclic Graph SVM (DAG SVM) method by adding the Discrete Wavelet Transform (DWT) algorithm for batik pattern recognition, so that by combining the two methods, the accuracy can be optimized.

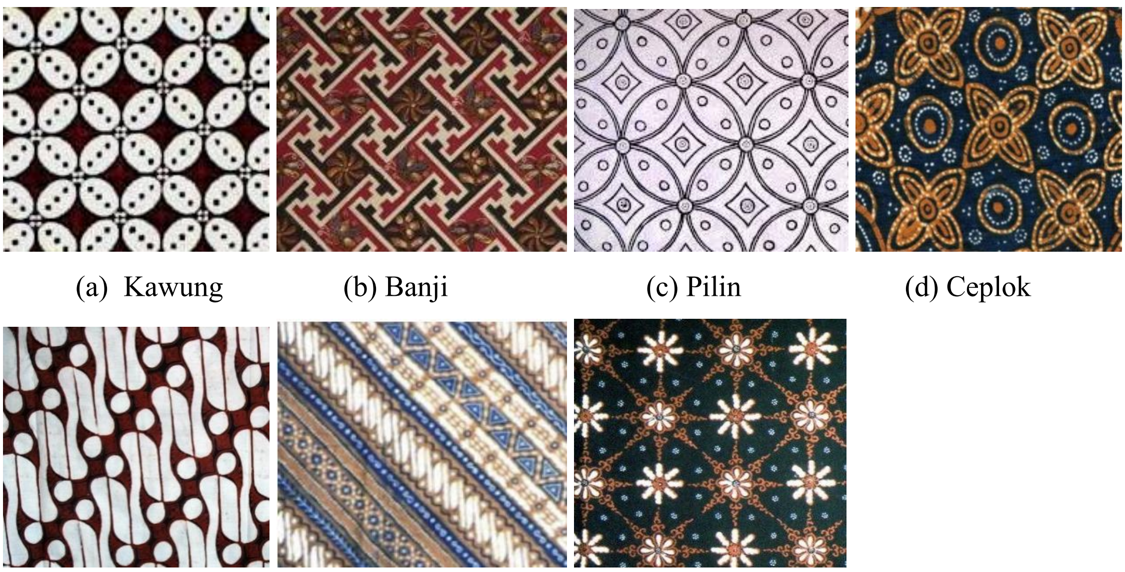
2. RESEARCH METHODS

2.1 Related Research

Research related to the application of the DAG SVM method has been conducted by Ramadhani [7]. His research discusses the automatic classification of textile motifs using the multi-class Support Vector Machine (SVM) method, namely One Against One (OAO), One Against All (OAA), and Directed Acyclic Graph (DAG), with image features extracted using Gabor Wavelet. The aim is to evaluate the performance of the three SVM variants and to test the effect of the number of scales and orientations of the Gabor filter on classification accuracy. The dataset consists of 120 textile images grouped into three motif categories: flowers, squares, and polka dots. The classification process is divided into two stages: training and testing, with three test scenarios, namely: (1) training image test, (2) cropped image test, and (3) cross-validation test (k-fold validation) with k values = 2, 4, and 8. The feature extraction method is carried out by forming a Gabor filter bank in three configurations: 2 scales–4 orientations, 4 scales–6 orientations, and 5 scales–8 orientations. The feature used is the magnitude of the convolution result between the image and the filter. The classification results show that for training images and cropped images, the accuracy reaches 100% in most tests, except for SVM OAA, which decreases slightly in the polka dot pattern to 90%. In the k-fold test, the SVM DAG and OAO models consistently show the highest accuracy of up to 78%, compared to SVM OAA, which only reaches 70%. In addition, the combination of Gabor filters with four scales and six orientations is proven to provide the best classification results.

2.2 Batik

Batik comes from the word "amba" which means to write, and "nitik" which means point. This means that the meaning of the combination of these words means to write with wax. So the process of making batik on cloth using a canting with a small tip gives the impression of someone writing dots [8]. The origin of batik in Indonesia is closely related to the history of the development of the Majapahit, Solo, and Yogyakarta kingdoms. There are many decorative variations of batik in Indonesia, which can be broadly divided into two main batik patterns, namely: geometric and non-geometric. Geometric batik patterns can be recognized because of the symmetry and repetition of horizontal, vertical, and diagonal directions that form angles between shapes, while non-geometric batik patterns do not show such symmetrical patterns [3]. Some geometric patterns that are often used include: kawung, banji, pilin, ceplok, parang, lereng, and nitik as shown in figure 1. And nongeometric patterns that are often used include: lung lungan, semen, pagersari, and taplak meja.



(a) Kawung (b) Banji (c) Pilin (d) Ceplok

(e) Parang (f) Lereng (g) Nitik

Figure 1. Geometric decorative pattern

2.3 Discrete Wavelet Transform

Wavelet transform is an improvement of the Fourier transform, which was first introduced in the 1980s by Morlet and Grossman. This wavelet transform is a mathematical function to represent data and a function as an alternative mathematical transformation to handle resolution problems [4][9]. This wavelet transform has two series in its development, namely Continuous Wavelet Transform (CWT) and Discrete Wavelet Transform (DWT). DWT describes a time scale of a digital signal obtained using digital filtering techniques [4][9][10]. The transformation process is carried out with the following steps: the original image is transformed into 4 new sub-images to replace it. Each sub-image is 1/4 of the size of the original image. The 3 sub-images in the upper right, lower left, and lower right positions will look like rough versions because they contain high frequencies from the original image. While 1 sub-image in the upper left will look smooth because it contains low-frequency components. From 1 sub-image with low frequency, it can be divided into 4 new sub-images. this process is carried out continuously with the desired transformation level [11][12][13]. In 2D images in figure 2, the transformation process is carried out on the rows first, then continued with the transformation on the columns.

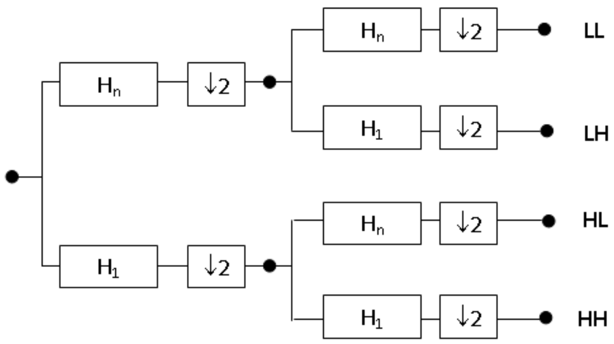


Figure 2. 2D Wavelet Transform

The results of the 2D wavelet transform are often made in the following schematic form:

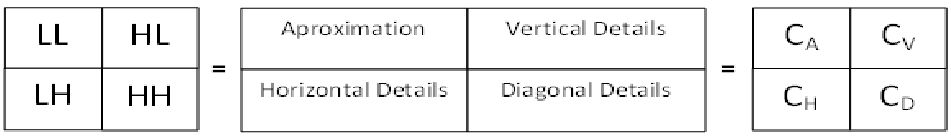


Figure 3. The results of the 2D wavelet transform

In figure 3 shows CA, CV, CH, and CD respectively denote the Approximation, Vertical, Horizontal, and Diagonal components.

2.4. Directed Acyclic Graph SVM (DAG SVM)

Directed Acyclic Graph SVM or DAG SVM is a new algorithm for class classification. For a problem with N classes, this DAG SVM builds N(N-1)/2 classifiers for each pair of classes [5]. DAG SVM works on the kernel-induced feature space and uses two classes with maximum margin on the hyperplane for each DDAG decision node. The DAG trains each node only on the labeled training subset, then the test point is evaluated against the decision node corresponding to the first and last elements of the list [9]. If the node chooses one of the two classes, then the other class is removed from the list, and the DAG continues to test the first and last elements of the new list. This process continues until the DAG ends at one class remaining in the list. The DAG evaluation process to find the best class from four classes is shown in figure 4:

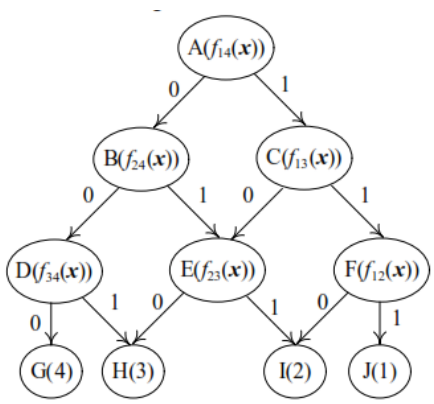


Figure 4. The process of finding the best class in a DAG

2.5. Pattern Recognition Process

The stages of the pattern recognition process start from data collection, data preprocessing, feature extraction, to classification. In the initial stage of data collection, the data collection process was carried out in the form of 7 batik pattern images, namely: kawung, banji, pilin, ceplok, parang, lereng, and nitik. The images obtained were 310 images with the composition for pattern recognition, divided into 270 for training data and 70 for testing data. After the data was collected, preprocessing was carried out by rearranging the image resolution to the specified size. Furthermore, at the feature extraction stage, the discrete wavelet transform (DWT) method was used to obtain features in the form of characteristics of each batik pattern. The next stage is classification, at the classification stage, the directed acyclic graph (DAG SVM) method was used. The last step is measuring accuracy using a confusion matrix. This research method is described in figure 5:

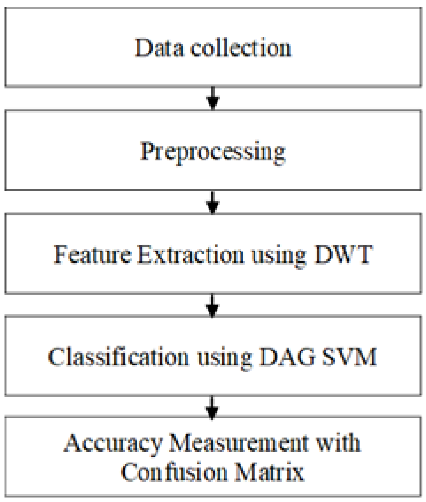


Figure 5. Research Method

2.5.1 Preprocessing

At this preprocessing stage, a process is carried out to change the resolution of the batik image to 160x160 pixels, then standardization is carried out for color, namely by changing the RGB color to grayscale, after the batik image is transformed into grayscale color, edge detection is carried out to obtain the batik pattern for each type. Below in figure 6 preprocessing stages.

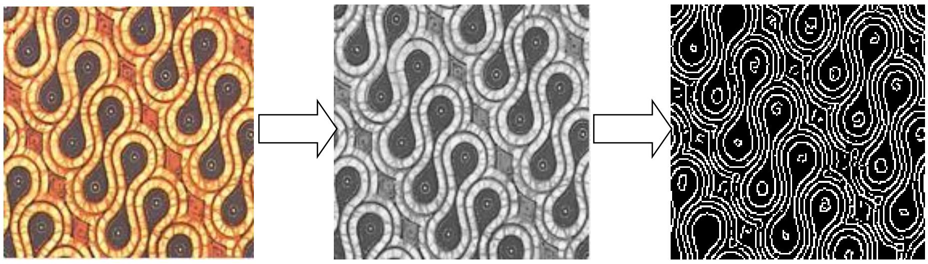


Figure 6. Preprocessing stage

2.5.2 Feature Extraction using DWT

After the preprocessing stage, the next stage is the preprocessed image will be taken its features, the method used in this feature extraction stage is discrete wavelet transform (DWT) where this method carries out the feature retrieval process by reducing the image dimensions from high dimensions to low dimensions by dividing the image into 4 subbands at each stage, namely: Approximation (CA), high horizontal frequency (CH), high vertical frequency (CV), and high diagonal frequency (CD). The following is an image of the results of the discrete wavelet transform up to level 3 shown in figure 7.

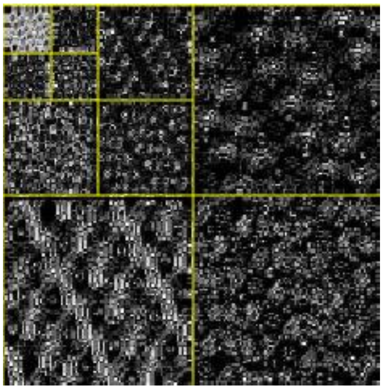


Figure 7. Level 3 discrete wavelet transform scheme

2.5.3 Classification using DAGSVM

After the features are formed, the next step is classification using DAG SVM This method is carried out at the training stage and testing stage. At the training stage, DAG SVM is used to form a model that will later be used for testing. After the model is formed, the next step in the testing stage is used for classification to determine the batik pattern that meets the criteria, so that at the pattern recognition stage, it can be described as follows:

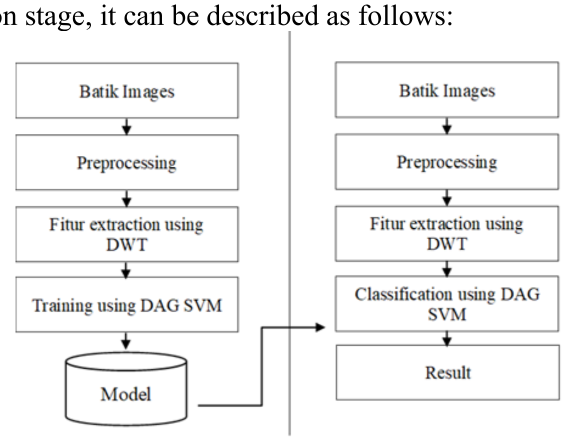


Figure 8. Stages of batik pattern recognition with DAG SVM

The classification phase in DAG SVM performs a binary comparison with each class, with the number of possibilities, namely k (k - 1) / 2, by comparing the first class with the last class in each phase, then moving left or right according to the results of the class comparison. For example, in this case, it consists of 7 classes, so this stage can be seen in table 1 as follow:

Table 1. Binary classification stages in DAG SVM

Class Set	Decision Function	Decision Result
{1,2,3,4,5,6,7}	f(1,7)	null
{2,3,4,5,6,7}	f(2,7)	not 1
{1,2,3,4,5,6}	f(1,6)	not 7
{3,4,5,6,7}	f(3,7)	not 1 and 2
{2,3,4,5,6}	f(2,6)	not 1 and 7
{1,2,3,4,5}	f(1,5)	not 6 and 7
{4,5,6,7}	f(4,7)	not 1, 2 and 3
{3,4,5,6}	f(3,6)	not 1, 2, and 7
{2,3,4,5}	f(2,5)	not 1,6, and 7
{1,2,3,4}	f(1,4)	not 5,6, and 7
{5,6,7}	f(5,7)	not 1,2,3, and 4
{4,5,6}	f(4,6)	not 1,2,3, and 7
{3,4,5}	f(3,5)	not 1,2,6, and 7
{2,3,4}	f(2,4)	not 1,5,6, and 7
{1,2,3}	f(1,3)	not 4,5,6, and 7
{6,7}	f(6,7)	not 1,2,3,4, and 5
{5,6}	f(5,6)	not 1,2,3,4, and 7
{4,5}	f(4,5)	not 1,2,3,6, and 7
{3,4}	f(3,4)	not 1,2,5,6, and 7
{2,3}	f(2,3)	not 1,4,5,6, and 7
{1,2}	f(1,2)	not 3,4,5,6, and 7

3. RESULTS AND DISCUSSION

3.1 Experiments and Results

The experiment was conducted using 310 data in the form of batik images consisting of 7 classes of batik motifs, then the 310 were divided into 240 for training data and 70 for testing data. Each image was then preprocessed by changing the resolution to 160x160, then the color was transformed from RGB to grayscale, and then edge detection was performed to obtain motifs in each class. Then, in the extraction feature, the discrete wavelet transform method was used to reduce high-dimensional images to lower dimensions. The extraction feature with DWT was carried out up to level 3 so that 20 features would be formed in each class, which would then be used in the classification stage. The next stage is classification using the directed acyclic graph SVM (DAG SVM) method. The steps taken at this stage were first to set the parameters for DAG SVM with the parameter settings gamma/γ=2-15 and penalty/C=28. Then the classification was carried out by testing the accuracy with 70 data for standard DAG SVM and DAG SVM optimized with discrete wavelet transform. To measure the level of accuracy, a confusion matrix is used. The results of measuring accuracy in the confusion matrix can be seen in table 2:

Table 2. Accuracy level measurement table

Method	True Positive (TP)	False Positive (FP)	True Negative (TN)	False Negative (FN)	Over All Accuracy (AC)
DAGSVM	58	12	0	0	0,83
DAGSVM+DWT	60	10	0	0	0.86

From the measurement using the confusion matrix, it can be seen that the accuracy level for standard DAGSVM is 83%, while DAGSVM with the addition of discrete wavelet transform has better accuracy, namely 86%, so it can be seen that the addition of the discrete wavelet transform method to DAG SVM can increase accuracy by up to 3%.

4. CONCLUSION

From the experiments that have been conducted by applying the discrete wavelet transform at the feature extraction stage and directed acyclic graph SVM in classification, it can be concluded that the experimental results are able to increase accuracy by up to 3%. Where the accuracy of the standard DAG SVM, which is 83% when tested with 70 data testing, can be increased to 86% with the addition of DWT and DAG SVM. This proves that the DWT method can perform feature extraction well

5. SUGGESTION

The application of the DWT method in feature extraction is able to produce good features, this is evidenced by the increase in the level of accuracy at the classification stage using DAG SVM. However, the method of feature extraction still needs to be improved. so that for further research, it is necessary to re-optimize the feature extraction stage by adding other algorithms so that the accuracy of batik pattern recognition with DAG SVM can be improved.

REFERENCES

[1] Rizal Fauzi, 2024, Ekspresi Budaya dalam Batik : Anlisis Penulisan dan Motif, Jurnal Inovasi dan kreativitas (JIKa), Vol. 4, No 2, pp. 43-54, e-ISSN 2807-8047 .

[2] Maulida Larasati, 2021, Pelestarian Budaya Batik Nusantara Sebagai Identitas Kultural Melalui Pameran Di Museum Batik Pekalongan Pada Masa Covid-19, Tornare - Journal of Sustainable Tourism Research, Vol. 3, No. 1, eISSN:2715-8004.

[3] Edi Sugiarto, 2023, Peningkatan Fitur Ekstraksi Berbasis Discrete Wavelet Transform dan Principal Component Analysis Pada Pengenalan Citra Batik, Jurnal Transformatika, Vol. 20, No. 2, P-ISSN: 1693-3656, E-ISSN: 2460-6731.

[4] Wendi Xie, 2021, Research on Wavelet Transform Technology and Image Processing Performance Based on Matlab, 2021 2nd Signal Processing and Computer Science (SPCS 2021), doi:10.1088/1742-6596/2031/1/012007.

[5] Huan Wu, Yong-Ping Zhao, Tan Hui-jun, 2021, A hybrid of fast K-nearest neighbor and improved directed acyclic graph support vector machine for large-scale supersonic inlet flow pattern recognition, Journal Aerospace Engineering 2021, Vol. 1, DOI: 10.1177/09544100211008601.

[6] S. Babu and A. K. Wadhwani, 2024, Epilepsy diagnosis using directed acyclic graph SVM technique in EEG signals, Traitement du Signal, vol. 41, no. 6, pp. 3163–3172, Dec. 2024, doi: 10.18280/ts.410632.

[7] Ramadhani, Fitri Arnia, Rusdha Muharar, 2020, Klasifikasi Otomatis Motif Tekstil Menggunakan Support Vector Machine Multi Kelas, Jurnal Teknologi Informasi Dan Ilmu Komputer (Jtiik), Vol. 07, No. 1, Page : 99-109, E-Issn: 2528-6579, Doi: 10.25126/Jtiik.202071428.

[8] Alicia, 2020,Filosofi Motif Batik Sebagai Identitas Bangsa Indonesia, Jurnal FOLIO Volume 1 No. 1 Februari 2020.

[9] Israa Hashim Latif, Sarah Haider Abdulredha, Sana Khalid Abdul Hassan. 2024, Discrete wavelet transform-based image processing: A review, Al-Nahrain Journal of Science, vol. 27, no. 3, pp. 109–125, [Online]. Available: https://anjs.edu.iq/index.php/anjs/article/view/2804

[10] Othman G, Zeebaree DQ, 2020, The applications of discrete wavelet transform in image processing: A review, Journal of Soft Computing and Data Mining, vol. 1, no. 2, pp. 31–43, Dec. 2020. [Online]. Available: https://publisher.uthm.edu.my/ojs/index.php/jscdm/article/view/7215

[11] Fiena Efliana Alfian, I Gede Pasek Suta Wijaya, Fitri Bimantoro, 2020, Identifikasi Iris Mata Menggunakan Metode Wavelet Daubechies Dan K-Nearest Neighbor, JTIKA, Vol. 2, No. 1, ISSN:2657-0327.

[12] Putri SW, Siregar TAN, Salsabilah RB, Saputra GE, 2024, Implementasi digital image processing menggunakan discrete Hermite wavelet filter technique dalam pemberian watermark pada citra, Jurnal Informatika dan Teknologi Informasi (JIFTI), vol. 6, no. 2, pp. 81–87, [Online]. Available: https://jifti.upnjatim.ac.id/index.php/jifti/article/view/160

[13] Pramita D, Indrawan IPY, 2021, Analisa orde pada discrete wavelet transform untuk aplikasi kompresi citra medis, Jurnal Teknik Informatika (JUTIK), vol. 7, no. 2, e-ISSN:2528-5211. DOI: https://doi.org/10.36002/jutik.v7i2.