JOIV : Int. J. Inform. Visualization, 6(4) - December 2022 835-841

INTERNATIONAL JOURNAL ON INFORMATICS VISUALIZATION

journal homepage : www.joiv.org/index.php/joiv

Application of Gray Scale Matrix Technique for Identification of Lombok Songket Patterns Based on Backpropagation Learning

Sudi Mariyanto Al Sasongko [a,*], Erni Dwi Jayanti [a], Suthami Ariessaputra [a]

[a] Department of Electrical Engineering, University of Mataram, Mataram, 83125, Indonesia

Corresponding author: *mariyantosas@unram.ac.id

Abstract— **Songket is a woven fabric created by prying the threads and adding more weft to create an embossed decorative pattern on a cotton or silk thread woven background. While songket from many places share similar motifs, when examined closely, the motifs of songket from various regions differ, one of which is in the Province of West Nusa Tenggara, namely Lombok Island. To assist the public in recognizing the many varieties of Lombok songket motifs, the researchers used digital image processing technology, including pattern recognition, to distinguish the distinctive patterns of Lombok songket. The Gray Level Co-occurrence Matrix (GLCM) technique and Backpropagation Neural Networks are used to build a pattern identification system to analyze the Lombok songket theme. Before beginning the feature extraction process, the RGB color image has converted to grayscale (grayscale), which is resized. Simultaneously, a Backpropagation Neural Network is employed to classify Lombok songket theme variations. This study used songket motif photos consisting of a sample of 15 songket motifs with the same color theme that was captured eight times, four of which were used as training data and kept in the database. Four additional photos were utilized as test data or data from sources other than the database. When the system's ability to recognize the pattern of Lombok songket motifs is tested, the maximum average recognition percentage at a 0° angle is 88.33 percent. In comparison, the lowest average recognition percentage at a 90° angle is 68.33 percent.**

Keywords— **Songket; Gray Level Co-Occurrence Matrix (GLCM); neural network; backpropagation.**

Manuscript received 14 Jan. 2022; revised 19 Jul. 2022; accepted 23 Aug. 2022. Date of publication 31 Dec. 2022.

I. INTRODUCTION

Songket is a woven fabric made by prying threads and adding additional weft threads (gold thread, silver thread, and colored cotton thread) to form an embossed decorative pattern on the woven base of cotton thread or silk thread. Both Indonesia and Malaysia are renowned for their cultural variety and rich heritage [1], [2]. Indonesia has many traditional fabrics in the form of songket woven cloth, an ancestral estate in West Nusa Tenggara, namely the Lombok Island. Songket Lombok has a distinctive motif and contains meaning and high aesthetic value [3], [4]. It is used for royal events or wedding ceremonies [5].

Songket has varied motifs, and almost every songket motif from various regions has the same motif. However, the songket motifs from multiple areas are different [6], [7]. The application can identify various types of Lombok songket motifs. It can help the people of Lombok and Indonesian society, in general, get to know the results of Lombok culture, especially Lombok songket. UNESCO has also designated batik as Indonesia's cultural heritage [8]–[10]. The diversity of Songket and batik motifs can be a medium of cultural learning for students [11].

Songket motifs in several regions in Indonesia have their characteristics, but when viewed directly, they appear to have similar patterns and motifs [3], [12]. Classification and recognition of songket motifs can be detected with artificial intelligence or similar techniques. Numerous scholars have included songket motifs in their work [13]–[15]. GLCM is a feature recognition that has been used in various fields [16]–[19]. GLCM is one of the algorithms used for image recognition, including songket images [20], [21]. GLCM has good results in the Classification of batik motifs[22].

Some algorithms are also combined with GLCM to obtain good results [23], [24]. The introduction of Indonesian batik patterns using the GLCM method and PCA feature extraction [25]. The batik pattern recognition application uses the K-Means algorithm to determine the types of recognized batik motifs [26]. GLCM is combined with the Salp Swarm Algorithm to obtain good segmented images[27]. Image recognition can also be improved by combining GLCM with an artificial neural network [28], [29].

Based on the research that has been done, the researcher developed a system for recognizing Lombok songket motifs which were processed using feature extraction techniques and artificial neural networks. The feature extraction method used is the Gray Level Co-occurrence Matrix (GLCM) feature extraction and motif recognition on songket using Backpropagation Neural Networks.

II. Material and Method

The stages of the research approach used in this study are six. It can be seen in Fig 1. First, a review of the songket literature and current studies; Image data acquisition; image size pre-processing; feature extraction using the GLCM approach; Backpropagation artificial neural network; the final step is to present the results and draw conclusions.

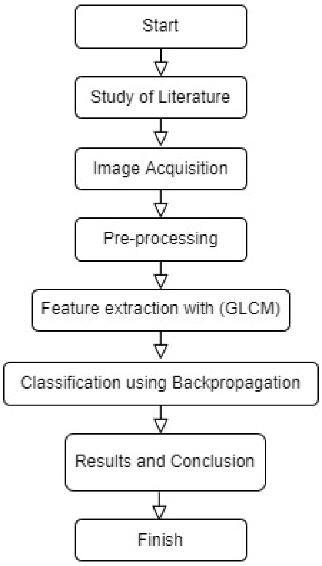

Fig. 1 Research stages

A. Songket

Woven cloth is one of Indonesian culture. Indonesia has three categories of traditional woven fabrics: weft tie, warp tie, and double ikat. One of the fabrics known to the public is the Lombok Songket Fabric (Sasak) which is included in the weft tie category. Songket, in general, can be defined as the process of lifting and joining metal threads (gold or silver) to form designs in the manufacture of woven fabrics [30]. Songket Lombok is decorated with various decorative motifs shown in Fig.2[31].

Fig. 2 a. geometric decoration b. variety of ornamental plants c. animal decoration d. human decoration, e., puppet decoration.

In general, Lombok songket decorations can be divided into several groups, namely:

- Geometric decoration in the form of straight-line motifs, curved lines, angular angle lines, crossed lines, lines forming plus signs, squares, triangles, quadrilaterals, hexagons, octagons, and circles
- Various ornamental plants are tree motifs, leaves, flowers, tendrils, and pineapples.
- Animal decoration in the form of butterfly, crab, gecko, horse, and bird motifs.
- Human decoration in the form of human motifs in a horseriding position
- The wayang decorations imitate the shape and appearance of the Sasak puppets in the Menak story.

B. Gray Level Co-Occurrence Matrix (GLCM)

Gray Level Co-Occurrence Matrix is a matrix whose elements are the number of pairs of pixels with a certain brightness level [32]. A distance separates the pixel pairs with an angle of inclination. In other words, the co-occurrence matrix is the probability that grey levels i and j will appear from two pixels separated at a distance d and angle. A neighboring pixel with a distance d between them can be located in eight different directions, shown in Fig 3.

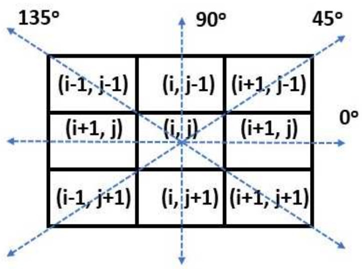

Fig. 3 The interaction between pixels in their neighborhood as a function of orientation and spatial distance

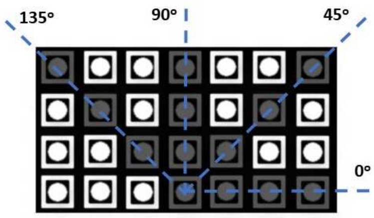

Fig. 4 Directions in calculating the Gray Level Co-Occurrence Matrix (GLCM)

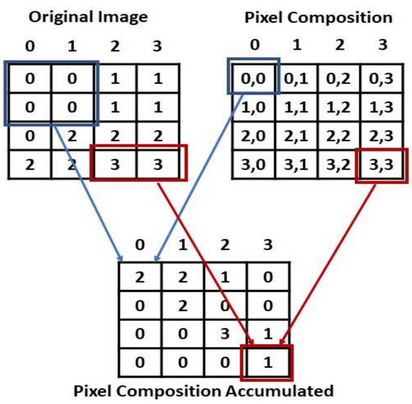

Fig. 5 The first step is changing the gray level co-occurrence matrix (GLCM)

The direction in which nearby pixels are used to represent distance can be chosen, for example, 135°, 90°, 45°, 0° or, as illustrated in Fig. 4. While Fig. 5 shows how to generate a matrix using the 0° direction and a distance of 1 pixel.

Characteristics or texture features of the image calculated from the co-occurrence matrix (CM) by stating the probability matrix $P(i,j) = CM(i,j)/\sum_{i=0}^{G-1}\sum_{j=0}^{G-1} CM(i,j)$ as follows [24]:

1) Mean is the average probability distribution *P(i,j)* which can be calculated based on sample *x* and *y*, where $\mu_{x=}\mu_{y}$.

$$\mu_{x=} \sum_{i=0}^{G-1} i \sum_{j=0}^{G-1} P(i,j) \quad (1)$$

$$\mu_{y=} \sum_{j=0}^{G-1} j \sum_{i=0}^{G-1} P(i,j) \quad (2)$$

2) Variance is the distribution of values or savings to the average value of the data (texture). The smaller the value of variance, the more homogeneous the surface, and vice versa. The variance can be calculated based on sample x and sample y, where

$$\sigma^2{}_x = \sigma^2{}_y \quad (3)$$

$$\sigma^2{}_x = \sum_{i=0}^{G-1}(i-\mu_x)^2 \sum_{j=0}^{G-1} P(i,j) \quad (4)$$

$$\sigma^2{}_y = \sum_{j=0}^{G-1}(j-\mu_y)^2 \sum_{i=0}^{G-1} P(i,j) \quad (5)$$

3) Energy uniformity quantifies local homogeneity and is equal to the reciprocal of entropy. This property is used to determine the degree of texture consistency. The energy value is between [0, 1], with 1 indicating a homogenous region.

$$Energy = \sum_{j=0}^{G-1}\sum_{i=0}^{G-1}(P(i,j))^2 \quad (6)$$

4) Entropy measures the level of randomness of the surface texture due to spatial or frequency disturbances. The entropy value can provide information about the surface features of a rough or smooth texture. The higher the entropy value is close to one, the higher the roughness level of the consistency; on the contrary, the entropy value is close to zero, the smoother the textured surface.

$$Energy = \sum_{j=0}^{G-1}\sum_{i=0}^{G-1}(P(i,j))^2 \quad (7)$$

5) Contrast is the variance of the co-occurrence matrix's local intensity values. The texture contrast is minimal if adjacent pixels have equal intensity levels or are near together.

$$Contrast = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1}(i,j)^2 P(i,j) \quad (8)$$

6) Dissimilarity is a measure that defines the variation in the intensity level of a pair of pixels in the image. Similar to contrast calculated by Euclidean distance, dissimilarity is calculated by city block distance.

$$Dissimilarity = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1}|i-j|\, P(i,j) \quad (9)$$

7) Homogeneity quantifies the degree to which the textural structure is repeated, where the weight value is the inverse of the contrast 8. Additionally, homogeneity is the inverse of dissimilarity 9. The variations in texture uniformity are pretty numerous. The importance of the co-occurrence matrix is concentrated along the matrix's diagonal. Homogeneity has the value range [0, 1]. The texture elements are diverse and dispersed uniformly over the texture region if the value is small.

$$Homogeneity = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1}\frac{P(i,j)}{1+(i-j)^2} \quad (10)$$

$$Homogeneity = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1}\frac{P(i,j)}{1+|i-j|} \quad (11)$$

Features of image textures are calculated from the co-occurrence (CM) matrix. The parameter is mean, variance, homogeneity, dissimilarity, contrast, entropy, and energy.

1). Songket Motif Image:

Image retrieval is done by taking the original photo of the songket and then converting it into a visual image to be used as an image trained and tested using a cellphone camera. Image data of songket weaving motifs used in this study were 15 songket motifs with the same color motif and nine songket motifs with different color motifs used as training.

TABLE I
SONGKET MOTIFS

Songket image			
Name	Bintang Empet	Bulan Begantung	Cerucut
Songket image			
Name	Dobel Terudat	Joget Sasak	Kembang Komak
Songket image			
Name	Kotak	Kupu-kupu	Merak
Songket image			
Name	Ocik	Pinggiran	Primitif
Songket image			
Name	Rang-rang Bianglalang	Rang-rang	Seriti

2). Preprocessing:

The image of the songket motif is initially a color image and pre-processing. It produces a better picture for processing later. This pre-processing stage consists of resizing. It is changing the image's size to increase or decrease its resolution. The input image used is an image measuring 4000 x 3000 pixels. The resulting matrix from a picture like this will be significant and require a long time in the computational process, so the size of the image in this study changed to 256 x 256 pixels. The image of the Lombok songket motif used is an RGB image which is then converted into a grayscale image to speed up the following process.

3). Feature extraction

Fig.6 is a feature extraction flowchart of Gray Level Co-Occurrence Matrix (GLCM) on a songket motif image taken using a mobile phone camera with a 12MP resolution.

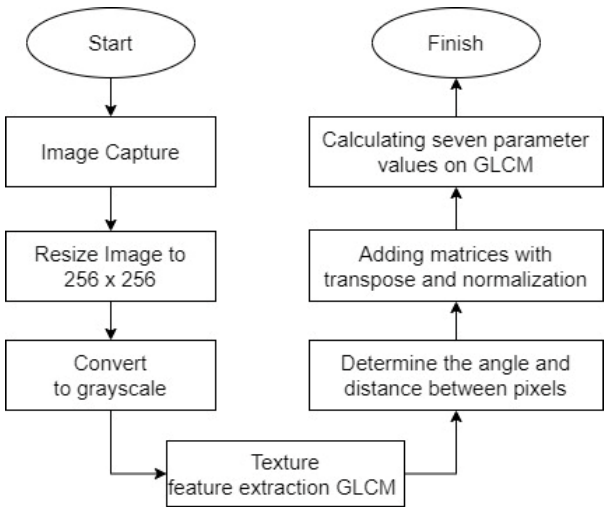

Fig. 6 Feature extraction process

The songket motif image has formed by 256 x 256 pixels. The resized songket image will go through a Red Green Blue (RGB) color conversion process into a photo with a grayscale where the processed image will contain the numbers 0-255. Next, the feature extraction is carried out the image by the GLCM with a matrix work area. Therefore, the matrix has combined angle values. It performs calculations using equations on seven existing parameters, such as: namely mean, variance, energy, entropy, contrast, dissimilarity, and homogeneity. The estimation of 7 parameters on the Gray Level Co-Occurrence Matrix (GLCM) was input by the training process and system testing.

C. Backpropagation

Backpropagation is a technique for creating artificial neural networks that use the notion of multi-layered networks. A backpropagation neural network comprises an input, output, and hidden layer between the input and output layers. The hidden layer may have many layers, which affects the training process of an artificial neural network.

Network training is used to train data sets that have been constructed, namely input data in the form of the GLCM technique for feature extraction. Simultaneously, the target data is calculated as the average of the training data. During training, the network settings varied, including the number of neurons in each hidden layer, the learning rate, and the momentum constant. The MSE and iteration length of each parameter is calculated.

$$\mathrm{MSE} = \left(\frac{1}{\mathrm{n}}\right) \times \sum(\mathrm{error})^2 \qquad (12)$$

Data collection was done by taking images of Lombok songket motifs as many as 15 songket motifs with the same motif and color and nine songket with different colors using a cellphone camera. In this study, 15 songket motifs with the same color motif take eight times, of which four images were used as training data and stored in the database. In contrast, the other four images were used as test data or data outside the database. This study will also be tested on nine songket motifs with the same motif in different colors.

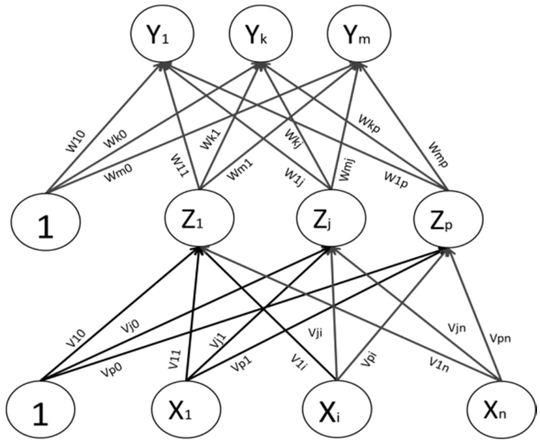

Fig. 7 Backpropagation architecture

The classification procedure is divided into two stages: data training and validation. The GLCM uses the data as input, and the output generated from this process is the name of each Lombok songket motif.

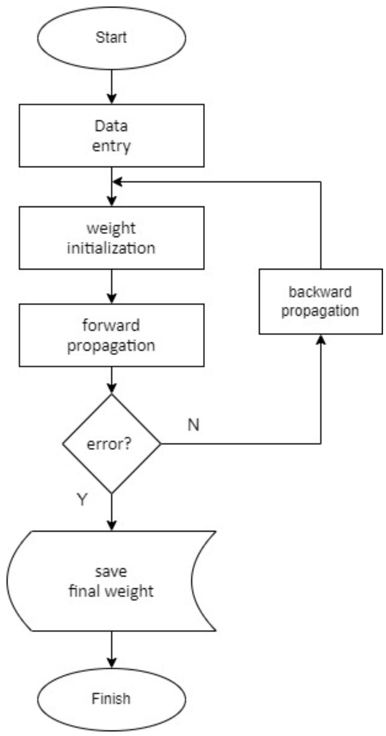

Fig. 8 Backpropagation flowchart

Before carrying out the training process for Backpropagation Neural Networks, it is necessary to pay attention to the network architecture. The network architecture is chosen with a constructive approach, with a small network with one hidden layer and then the number of hidden units and additional weights until the desired solution.

Each neuron in the input layer consists of the feature extraction results with the Gray Level Co-Occurrence Matrix (GLCM) method and forwards it to the neurons in the hidden layer above it. The number of neurons in the input layer corresponds to the number of variables selected as network input and one biased neuron.

Testing the network by one hidden layer is used to determine The number of neurons in the hidden layer. The number of neurons for the hidden layer is m neurons plus one bias neuron. The activation function used is binary sigmoid activation. The output layer consists of a neuron that produces output in the form of the result of recognizing songket motifs

D. Grayscale color conversion

In this process, the songket motif color image has converted from Red Green Blue (RGB) into a grey or grayscale image. The purpose of color conversion is to facilitate image processing in the feature extraction process.

III. Results and Discussion

The songket motif recognition training process uses Backpropagation Artificial Neural Network (ANN) and Gray Level Co-Occurrence Matrix (GLCM) feature extraction by creating a matrix work area with angle values 0°, 45°, 90°, and 135°. In the network training process, several variations of parameter changes in ANN Backpropagation are carried out, namely hidden layer neurons, learning rates, momentum, and epochs to see how the system works and the effect of parameter changes on the error value and training time. The number of songket motifs recognized 15 with the same motifs and colors, with each image data of 4 songket motifs. The training data used during the training process is 60 songket motif image data.

A. Variation of hidden layer neurons

TABLE II
Results of Neuron Hidden Layer Variation Training

Hidden Layer			error			
Layer 1 (neuron)	Layer 2 (neuron)	Layer 3 (neuron)	0°	45°	90°	135°
50	50	1	0.0133	0.0551	0.476	0.0245
60	20	1	0.011	0.211	0.9	0.204
60	30	1	0.0638	0.0536	0.437	0.185
60	50	1	0.0217	0.122	0.901	0.288
65	35	1	0.016	0.0247	0.668	0.199
70	30	1	0.0156	0.0055	0.495	0.0734
70	50	1	0.0335	0.0132	0.446	0.0744
75	65	1	0.00603	0.0159	0.454	0.0363
90	10	1	0.0209	0.093	0.709	0.0311
90	30	1	0.00933	0.0187	0.203	0.0118

Variations in training several hidden layer neuron values and GLCM feature extraction using a value of Lr=0.1; Goal= 0.001; Epoh= 50000; Mc=0.5. The training results to see the best-hidden layer values can be seen in table 2. It can be seen that the variation in the value of the best-hidden layer neurons used is the variation of the hidden layer neurons at an angle of 45°, namely for layer 1 = 70 neurons, layer 2 = 30 neurons, and layer 3 = 1 neuron. In training, an error value of 0.0055 was obtained.

B. Variation of learning rate

Variations in the training of several learning rate values and GLCM feature extraction using Layer 1 values = 70 neurons; layers 2=30; layer 3=1 neurons; 0.1; Goal= 0.001; Epoh= 50000; Mc=0.5. The training results to see the best learning rate can be seen in table 3.

TABLE III
Training Results of Variation of Learning Rate and Extraction of GLCM Characteristics

Learning Rate	error			
	0°	45°	90°	135°
0.1	0.00801	0.0055	0.495	0.0734
0.2	0.00805	0.00549	0.725	0.058
0.3	0.016	0.00703	0.896	0.0136
0.4	0.00804	0.00551	0.562	0.0585
0.5	0.0123	0.0195	0.508	0.00441
0.6	0.0126	0.532	0.525	0.0277
0.7	0.008	0.00873	0.508	0.00322
0.8	0.00735	0.00831	0.562	0.0595
0.9	0.00996	0.0056	0.508	0.0136

From the results of the training of parameter variations with changes in the learning rate (lr) from 0.1 to 0.9 on the Backpropagation Neural Network, As can be seen, the fluctuation of the optimum learning rate value employed is equivalent to the variation of the learning rate at a 135° angle with a learning rate of 0.7. During training, a matter of 0.00322 was achieved for the error.

C. Variation of Momentum

Variations in training some momentum values and GLCM feature extraction using Layer 1 values = 70 neurons; layers 2=30; layer 3=1 neuron; Lr=0.1; Goal= 0.001; Epoch = 50000. The training results to see the best momentum value can be seen in table 4.

TABLE IV
Results of GLCM Momentum Variation and Extraction Training

Momentum (m_c)	error			
	0°	45°	90°	135°
0.5	0.00801	0.0055	0.495	0.0734
0.6	0.00802	0.00719	0.42	0.0818
0.7	0.00653	0.00695	0.434	0.00632
0.8	0.00869	0.00589	0.328	0.0177
0.9	0.00501	0.0154	0.538	0.0298

From the results of the training of parameter variations with changes in momentum value (mc) from 0.5 to 0.9 on the Backpropagation Neural Network, it can be seen that the best momentum value variation used is the momentum variation at an angle of 0°, with a momentum value of 0.9. In training, an error value of 0.00501 was obtained.

D. Variations of the Epoch

Variations in training several learning rate values and GLCM feature extraction using Layer 1 values = 70 neurons; layers 2=30; layer 3=1 neuron; Lr=0.1; Goal= 0.001; Mc=0.5. The training results to see the best epoch value can be seen in table 5. The best epoch value variation used is the epoch variation at an angle of 45°, with an epoch value of 100000. In this training, an error value of 0.00172 was obtained.

TABLE V
TRAINING RESULTS OF EPOCH VARIATION AND EXTRACTION OF GLCM CHARACTERISTICS

epoch	error			
	0°	45°	90°	135°
50000	0.00801	0.0055	0.495	0.0734
60000	0.00673	0.00662	0.444	0.0436
70000	0.0058	0.00314	0.397	0.00902
80000	0.00516	0.00252	0.376	0.0232
90000	0.0047	0.00415	0.248	0.00815
100000	0.00428	0.00172	0.273	0.0223

In the training process, the learning rate has changed from 0.1-to 0.9. The results do not affect the output of the resulting error. Changes in the learning rate value only affect the speed of training. After obtaining the best parameters in the network training process by looking at the best MSE value calculated using equation 1, the next step is testing the introduction of Lombok songket motifs trained and untrained.

E. Testing the Data in the Database

The stage of testing the Backpropagation Artificial Neural Network (ANN) includes testing inside the database and testing outside the database using 15 songket motifs with the same motif and color and nine songket motifs with the same color motif being different.

The result of testing data songket in the database is shown in Table 6. Based on the test results, this system can recognize songket motifs well. The average recognition rate is 100%.

F. Testing Data Outside the Database (Using Data Testing)

The result of testing data songket outside the database is shown in Table 7. It can be seen that the average recognition of songket motif recognition outside the database has varying values. The highest average recognition percentage is at an angle of 0° at 88.33%, and the lowest percentage recognition rate at an angle of 90° is 68.33%.

TABLE VI
THE RESULTS OF TESTING THE IMAGE DATA IN THE DATABASE

No	Motif Name	Number of Songket Motif Images	Recognized motif (%)			
			0°	45°	90°	135°
1	Bintang Empet	4	100	100	100	100
2	Bulan Begantung	4	100	100	100	100
3	Cerucut	4	100	100	100	100
4	Dobel Terudat	4	100	100	100	100
5	Joget Sasak	4	100	100	100	100
6	Kembang Komak	4	100	100	100	100
7	Kotak	4	100	100	100	100
8	Kupu-Kupu	4	100	100	100	100
9	Merak	4	100	100	100	100
10	Ocik	4	100	100	100	100
11	Pinggiran	4	100	100	100	100
12	Primitif	4	100	100	100	100
13	Rang-rang Bianglalang	4	100	100	100	100
14	Rang-rang	4	100	100	100	100
15	Seriti	4	100	100	100	100
	Total	60	100	100	100	100

TABLE VII
TESTING RESULTS ARE BASED OUTSIDE THE DATABASE

No	Motif Name	Number of Songket Motif Images	Recognized motif (%)			
			0°	45°	90°	135°
1	Bintang Empet	4	50	100	25	100
2	Bulan Begantung	4	100	75	75	100
3	Cerucut	4	100	100	75	100
4	Dobel Terudat	4	100	100	100	100
5	Joget Sasak	4	50	50	75	100
6	Kembang Komak	4	75	100	75	75
7	Kotak	4	75	75	25	100
8	Kupu-Kupu	4	100	50	25	50
9	Merak	4	100	25	50	25
10	Ocik	4	100	75	50	100
11	Pinggiran	4	100	100	100	75
12	Primitif	4	50	100	75	100
13	Rang-rang Bianglalang	4	100	75	100	75
14	Rang-rang	4	75	75	75	25
15	Seriti	4	100	100	100	100
	Total	60	88.33	80	68.33	80

G. Testing the Data Using the Same Motif Data with Different Colors

Backpropagation is the testing stage with the same songket motif in different colors. The results are shown in Table 8.

TABLE VIII
TESTING DATA OUTSIDE THE DATABASE

No	Motif Name	Number of Songket Motif	Recognized motif		Unrecognized Motif (%)
			Amount	Level of recognition	
1	Bintang Empet	1	0	0	100
2	Bulan Getap	1	0	0	100
3	Dobel Terudat	1	0	0	100
4	Kotak	1	0	0	100
5	Kupu-Kupu	1	0	0	100
6	Petak	1	0	0	100
7	Rang-rang	1	0	0	100
8	Rumah sasak	1	0	0	100
9	Subahnale	1	0	0	100
	Total	9	9	0	100

The testing uses Gray Level Co-Occurrence Matrix (GLCM) feature extraction at an angle of 0° because the tests were carried out on songket motif data with the same motif and color level. The best recognition obtained is at an angle of 0°. In testing the recognition of songket motifs with Backpropagation ANN using variations in the number of hidden layer neurons, namely for layer 1 = 70 neurons, layer 2 = 30 neurons, and layer 1 = 1 with a learning rate value of 0.1, momentum 0.5, and epoch 500000. Table 8 shows that the songket motif is unrecognized by Backpropagation ANN so the average percentage of system recognition is 0%. The findings of this study can be used to develop an android-based information system for detecting Lombok songket motifs. Furthermore, deep learning techniques can be used to improve this method.

IV. Conclusion

The Lombok songket motif recognition system with feature extraction algorithm Gray Level Co-Occurrence Matrix (GLCM) and Backpropagation can recognize songket motifs with an average recognizing rate of 88.33%. Furthermore, this system was tested with the same motif and color, and it has a recognition rate of 88.33% at an angle of 0° and 80% at an angle of 45°. Next, at a test angle of 90° and 135°, an recognition of 68.33% and 80% was obtained, then tested using songket with the same motif but with different colors in the database. The results show that at an angle of 0°, this system unsuccessfully recognizes all the test data. Additionally, it can provide a guide for developing Lombok songket detecting applications.

References

[1] L. Leonardo, "Penerapan Metode Filter Gabor Untuk Analisis Fitur Tekstur Citra Pada Kain Songket," *J. Sist. Komput. dan Inform.*, vol. 1, no. 2, 2020, doi: 10.30865/json.v1i2.1942.

[2] Y. Y, M. R. Yusof, and Y. Ibrahim, "Songket : the Linkage Between Heritage and Tourism in Malaysia," *Asian People J.*, vol. 1, no. 2, 2018.

[3] H. Hambali, M. Mahayadi, and ..., "Classification of Lombok Songket Cloth Image Using Convolution Neural Network Method (Cnn)," *Pilar Nusa Mandiri ...*, no. 85, pp. 149–156, 2021, doi: 10.33480/pilar.v17i2.2705.

[4] B. Imran and M. M. Efendi, "The Implementation of Extraction Feature Using GLCM and Back-Propagation Artificial Neural Network to Clasify Lombok Songket Woven Cloth," *J. Techno Nusa Mandiri*, vol. 17, no. 2, 2020, doi: 10.33480/techno.v17i2.1680.

[5] M. Janpourtaher, "Scientific approach of preservation treatment and restoration procedures on historical royal Songket Sarong," *Int. J. Conserv. Sci.*, vol. 10, no. 1, 2019.

[6] A. C. Siregar and B. C. Octariadi, "Classification of Sambas Traditional Fabric 'Kain Lunggi' Using Texture Feature," *IJCCS (Indonesian J. Comput. Cybern. Syst.*, vol. 13, no. 4, 2019, doi: 10.22146/ijccs.49782.

[7] F. Wijayanti, T. Rohendi Rohidi, and K. Utara, "Palembang Songket Fabric Visual Motif," *Cathar. J. Arts Educ.*, vol. 8, no. 4, pp. 429–436, 2019.

[8] H. Fonda, "Klasifikasi Batik Riau dengan Menggunakan Convolutional Neural Networks (CNN)," *J. Ilmu Komput.*, vol. 9, no. 1, 2020, doi: 10.33060/jik/2020/vol9.iss1.144.

[9] F. T. Maharani and Z. Lynch, "The Implementation of the POPMAR (Policy, Organising, Planning and Implementing, Measuring Performance, Audit and Reviewing) Model in Occupational Health and Safety Risk Management in an Indonesian Batik Company," *Indones. J. Occup. Saf. Heal.*, vol. 10, no. 3, 2021, doi: 10.20473/ijosh.v10i3.2021.420-432.

[10] H. Warsono, T. Afrizal, and R. J. Pinem, "Conserving heritage craft in meeting contemporary and demand issues: A collaborative governance approach," *Int. J. Entrep.*, vol. 25, no. 1, 2021.

[11] J. Junaidi, N. Pramestie Wulandari, and D. Hamdani, "Subahnale dan Rang-rang Pembelajaran Matematika SMP," *Griya J. Math. Educ. Appl.*, vol. 1, no. 4, 2021, doi: 10.29303/griya.v1i4.102.

[12] R. C. I. Prahmana and U. D'Ambrosio, "Learning geometry and values from patterns: Ethnomathematics on the batik patterns of yogyakarta, indonesia," *J. Math. Educ.*, vol. 11, no. 3, 2020, doi: 10.22342/jme.11.3.12949.439-456.

[13] S. Devella, Y. Yohannes, and F. N. Rahmawati, "Implementasi Random Forest Untuk Klasifikasi Motif Songket Palembang Berdasarkan SIFT," *JATISI (Jurnal Tek. Inform. dan Sist. Informasi)*, vol. 7, no. 2, pp. 310–320, Aug. 2020, doi: 10.35957/jatisi.v7i2.289.

[14] Y. Yohannes, S. Devella, and A. H. Pandrean, "Penerapan Speeded-Up Robust Feature pada Random Forest Untuk Klasifikasi Motif Songket Palembang," *J. Tek. Inform. dan Sist. Inf.*, vol. 5, no. 3, Jan. 2020, doi: 10.28932/jutisi.v5i3.1978.

[15] M. A. Rasyidi, R. Handayani, and F. Aziz, "Identification of batik making method from images using convolutional neural network with limited amount of data," *Bull. Electr. Eng. Informatics*, vol. 10, no. 3, 2021, doi: 10.11591/eei.v10i3.3035.

[16] Z. E. Fitri, A. Madjid, and M. Nanda, "Penerapan Neural Network untuk Klasifikasi Kerusakan Mutu Tomat," *J. Rekayasa Elektr.*, vol. 16, no. 1, pp. 44–49, 2020, doi: 10.17529/jre.v16i1.15535.

[17] J. M. Challab and F. Mardukhi, "A hybrid method based on LSTM and optimized SVM for diagnosis of novel coronavirus (COVID-19)," *Trait. du Signal*, vol. 38, no. 4, pp. 1061–1069, Aug. 2021, doi: 10.18280/ts.380416.

[18] R. S. Patil and N. Biradar, "Automated mammogram breast cancer detection using the optimized combination of convolutional and recurrent neural network," *Evol. Intell.*, vol. 14, no. 4, pp. 1459–1474, 2021, doi: 10.1007/s12065-020-00403-x.

[19] Y. Park and J. M. Guldmann, "Measuring continuous landscape patterns with Gray-Level Co-Occurrence Matrix (GLCM) indices: An alternative to patch metrics?," *Ecol. Indic.*, vol. 109, Feb. 2020, doi: 10.1016/j.ecolind.2019.105802.

[20] I. Amalia, "Ekstraksi Fitur Citra Songket Berdasarkan Tekstur Menggunakan Metode Gray Level Co-occurrence Matrix (GLCM)," *J. Infomedia*, vol. 3, no. 2, 2018, doi: 10.30811/jim.v3i2.715.

[21] M. Sholihin, "Classification of Batik Lamongan Based on Features of Color, Texture and Shape," *Kursor*, vol. 9, no. 1, 2018, doi: 10.28961/kursor.v9i1.114.

[22] I. P. G. S. Andisana, M. Sudarma, and I. M. O. Widyantara, "Pengenalan Dan Klasifikasi Citra Tekstil Tradisional Berbasis Web Menggunakan Deteksi Tepi Canny, Local Color Histogram Dan Co-Occurrence Matrix," *Maj. Ilm. Teknol. Elektro*, vol. 17, no. 3, 2018, doi: 10.24843/mite.2018.v17i03.p15.

[23] C. Jatmoko and D. Sinaga, "A Classification of Batik Lasem using Texture Feature Ecxtraction Based on K-Nearest Neighbor," *J. Appl. Intell. Syst.*, vol. 3, no. 2, 2019, doi: 10.33633/jais.v3i2.2151.

[24] N. Nurhalimah, I. G. P. Suta Wijaya, and F. Bimantoro, "Klasifikasi Kain Songket Lombok Berdasarkan Fitur GLCM dan Moment Invariant Dengan Teknik Pengklasifikasian Linear Discriminant Analysis (LDA)," *J. Teknol. Informasi, Komputer, dan Apl. (JTIKA)*, vol. 2, no. 2, 2020, doi: 10.29303/jtika.v2i2.98.

[25] 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," *Int. J. Electr. Comput. Eng.*, vol. 10, no. 2, pp. 2045–2053, 2020, doi: 10.11591/ijece.v10i2.pp2045-2053.

[26] A. Zahra, E. Ernawati, and E. P. Purwandari, "Perbandingan Metode K-Means Clustering dan Discrete Cosine Transform Untuk Kompresi Citra Batik Besurek Motif Gabungan," *Pseudocode*, vol. 5, no. 2, 2018, doi: 10.33369/pseudocode.5.2.46-55.

[27] Z. Xing and H. Jia, "Multilevel Color Image Segmentation Based on GLCM and Improved Salp Swarm Algorithm," *IEEE Access*, vol. 7, 2019, doi: 10.1109/ACCESS.2019.2904511.

[28] K. Chandraprabha and S. Akila, "Texture Feature Extraction for Batik Images Using GLCM and GLRLM with Neural Network Classification," *Int. J. Sci. Res. Comput. Sci. Eng. Inf. Technol.*, 2019, doi: 10.32628/cseit195322.

[29] O. Sudana, I. P. A. Bayupati, and D. G. Yudiana, "Classification of Maturity Level of the Mangosteen using the Convolutional Neural Network (CNN) Method," *Int. J. Adv. Sci. Technol.*, vol. 135 (20), no. February, 2020, doi: 10.33832/ijast.2020.135.04.

[30] F. A. Ahda and F. A. Rahman, "Perancangan Infografis Songket Lombok," *J. Desain Komun. Vis. Asia*, vol. 1, no. 1, 2017, doi: 10.32815/jeskovsia.v1i1.307.

[31] R. Aprianti, K. Evandari, R. A. Pramunendar, and M. Soeleman, "Comparison of Classification Method on Lombok Songket Woven Fabric Based on Histogram Feature," 2021, doi: 10.1109/iSemantic52711.2021.9573223.

[32] P. N. Andono and E. H. Rachmawanto, "Evaluasi Ekstraksi Fitur GLCM dan LBP Menggunakan Multikernel SVM untuk Klasifikasi Batik," *J. RESTI (Rekayasa Sist. dan Teknol. Informasi)*, vol. 5, no. 1, 2021, doi: 10.29207/resti.v5i1.2615.