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Digital Image Processing to Detect Sumba Woven Fabric Contour Using Gray Level Co-occurrence Matrix and Self Organizing Map

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ABSTRACT

Sumba woven cloth is one of the cultural heritages of the island of Sumba. Based on its manufacture, the classification process for Sumba woven fabrics is based on the identification of colors or motifs. However, the classification process is not an easy process. In addition to the classification process, the wider community also does not get much information about Sumba woven fabrics clearly, therefore digital image processing technology is needed to build a system that can overcome the problems faced. The image of the Sumba woven fabric sample is converted to grayscale and resized, then segmented using Sobel detection. Then extracted using Gray level co-occurrence matrix (GLCM). After extraction, it will be classified using a Self Organizing Map (SOM). Based on the results of this study, it was concluded that the accuracy of the validation test was 80%, and the program was successful.

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1. INTRODUCTION

One of the handicrafts in the form of cloth is weaving. Weaving is usually made of yarn (cotton and silk), by inserting the weft crosswise on the warp thread [1]. There are various types of weaving in the province of NTT, namely Ikat weaving, Sotis weaving or lotis weaving, Buna weaving, and Songket weaving. NTT woven cloth as cultural heritage is used by various groups, especially as a custom (marriage and death) and also as a fashion model. The quality of production is determined by the material, origin, motif, and pattern of the woven fabric. There are 7,377 weaving motifs in the province of NTT, with a variety of motifs and patterns of woven fabrics that are influenced by the geographical location of the islands, natural conditions, and community structures spread across the province of East Nusa Tenggara [2], one of which is one on the island of Sumba.

Sumba Island is one of the islands in the province of East Nusa Tenggara, consisting of 4 regencies, with an area of the island of Sumba is 11,005.62 km² or 11,005,620 Ha [3]. In 2010, the population of Sumba island was 685,186 people [4]. The people of the island of Sumba, generally live from livestock and farming activities. However, another source of livelihood that is no less important is weaving woven cloth. The activity of weaving woven cloth has been integrated with the customs of the Sumbanese people, especially women in Sumba since hundreds of years ago [5]. On the island of Sumba, weaving is used as one of the handicrafts of the people who have a traditional culture of woven cloth that still survives and develops today. Woven fabrics cannot be separated from the people of Sumba because woven fabrics, apart from being the result of handicrafts and a source of livelihood, are also part of everyday life that is always present in the life values of the Sumbanese people [6]. In each Sumba woven fabric, there are different characteristics, both from the coloring process and the motifs contained in the weaving. There are several motifs of woven fabrics on the island of Sumba, namely human motifs, old kaka, chickens, deer (ruhha), horses, turtles, crocodiles, butterflies, lions, mamoli, flowers, horsetails, and shrimp. Each motif contained in the cloth and sarong has a different meaning and value. For example, the turtle motif reflects loyalty, the mamoli reflects female fertility, the chicken reflects an animal that reminds time, the crocodile reflects male strength, and so on [7].

Based on the manufacture, the process of classification of Sumba woven fabrics is usually carried out by identifying colors and motifs. However, the classification process is not easy, because the classification process requires time and also skilled personnel in the field of Sumba woven fabrics. Currently, the manual method is used to see the characteristics of a Sumba woven fabric, where a ruler, magnifying glass, and other manual tools are used to identify the Sumba woven fabric motif. But this classification requires very long manual work. In addition to the calcification process, the wider community also does not get much information about Sumba woven fabrics clearly, because it is necessary to introduce the types of Sumba woven fabrics so that people can know or recognize the types of Sumba woven fabrics based on their manufacture. Therefore, it is necessary to conduct a more in-depth study using digital image processing technology to build a system that can determine whether there are image differences between Sumba woven fabrics which fall into the categories of Ikat, Lotis/Sotis, and Songket weaving.

This study, based on a sample of Sumba woven fabric images, was carried out by changing the color image to grayscale, then resized and segmented using Sobel detection. Next, image feature extraction will be performed using Gray level co-occurrence matrix (GLCM) to look for values such as energy, contrast, homogeneity, and correlation. After the extraction of image features, the extracted data will be classified using Self Organizing Map (SOM). Various studies have been carried out in classifying NTT woven fabrics using image processing techniques. The k-nearest neighbor (KNN) method with Sobel detection segmentation is used in [8], and [9] using Multiclass Support Vector Machine (MSVM).

Using a different method, this study aims to classify three classes of Sumba weaving images, which consist of ikat images, Lotis/Sotis weaving, and Songket weaving. This study uses Sobel edge detection segmentation, to detect the edges of an image. The feature extraction process of the segmented image uses the GLCM method and the classification uses the SOM.

2. RESEARCH METHOD

The method proposed in this study consists of image preprocessing, image segmentation with Sobel edge detection, image feature extraction with Gray Level Co-occurrence Matrix (GLCM), SOM model training, and image testing (Figure 1). The steps taken to classify the types of Sumba woven fabric images start from entering the Sumba woven image and doing image preprocessing and image segmentation. Image feature extraction process with GLCM to get feature extraction results. SOM model training and image testing were carried out to obtain classification results in determining the three types of images of Sumba woven fabrics. The use of the SOM method is expected to produce the best classifications, such as the inner class classification [10], painting style [11], and Community Welfare Level Grouping with deep [12].

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2.1. Sumba Woven Fabric

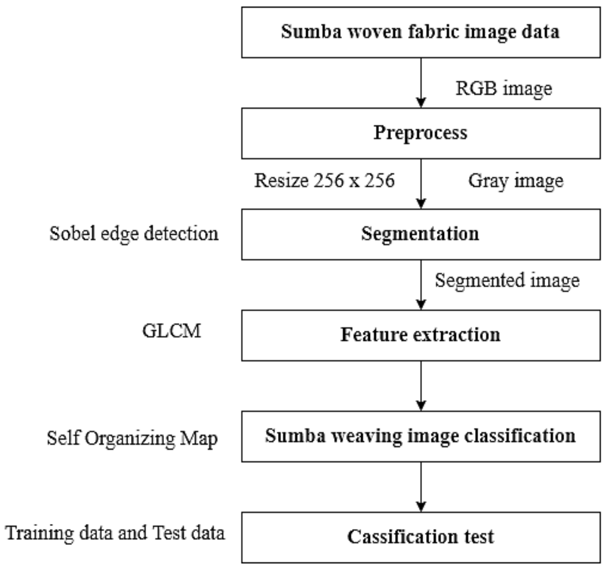

Figure 1. Research Flowchart

The data used in this research was taken from the weaving gallery at the Regional National Craft Council (DEKRANASDA) NTT and consisted of 100 images of Sumba woven fabrics with 30 images of Ikat weaving, 40 images of Sotis/Lotis weaving, and 30 Songket weaving. The image data is divided by the composition of 80% training images or as many as 80 images, 20% test images, or as many as 20 images. Examples of these three types of images of Sumba woven fabrics can be seen in Figure 2. Image preprocessing is carried out after the RGB image data is entered. The process carried out is to convert the image color space from the original RGB into a grayscale image color space. After doing the color conversion, the image will be resized to a size of 256 x 256. The next process is to extract the grayscale image for use in the segmentation process. The purpose of preprocessing is to transform data into a format that is easier and more efficient to process to obtain more accurate values and reduce computation time for large-scale problems, thereby reducing the value of the data without changing the information it contains. The process carried out at this stage is resizing or changing the dimensions to a smaller size with the aim that the system can easily detect the texture of the Sumba woven fabric. Next, the RGB image conversion (red, green, blue) is converted into a grayscale image so that it can be converted by a computer [13].

2.2. Segmentation

Digital image segmentation is the division of a digital image area into smaller parts based on the location of pixels and their intensity that are still close together. The image segmentation process aims to group object pixels into regions that represent objects [14]. At this stage, the image that has gone through the preprocessing stage and has been resized will be segmented by detecting edges using the Sobel detection method. The segmentation process carried out will produce edge detection in the form of a binary image.

(a) (b) (c)

Figure 2. Type of Sumba Weaving Image; a) ikat weaving, b) sotis/lotis weaving, c) songket weaving.

The Sobel method is a development of Robert's method which is given one zero buffer by using an High Pass Filter (HPF) filter. The advantage of this Sobel method is the ability to reduce noise before performing Kernel edge detection. The filters used in this Sobel method are [8].

2.3. Image Extraction

The feature extraction process is to obtain information from an image where the information will be used as a parameter for the prediction process using the SOM classification [15]. In this research, Gray Level CoOcurrency Matrix (GLCM) is used to extract the image from the image, the reason for using this algorithm is because GLCM is easier to implement for texture analysis and very easy to distinguish based on the texture of the image. Gray Level Co-Occurrence Matrix (GLCM) or co-occurrence matrix is a statistical method that can be used to analyze textures. A co-Occurrence Matrix means a matrix that describes the neighboring correlation between pixels in an image with various orientation directions and spatial distances [16]. The co-occurrence matrix is formed from an image, looking at paired pixels that have a certain intensity. This method is used based on the hypothesis, that there will be a repetition of configurations or pairs of gray levels in a texture. Orientation is expressed in degrees and distance is expressed in pixels. The orientation is formed in four angular directions with angle intervals of 45°, namely 0°, 45°, 90°, and 135° (Figure 3) [17].

Texture analysis is very good at presenting image textures with measurable parameters, such as energy, contrast, correlation, and homogeneity [13]. The calculation of the four features can be described as formula 1-4 [18].

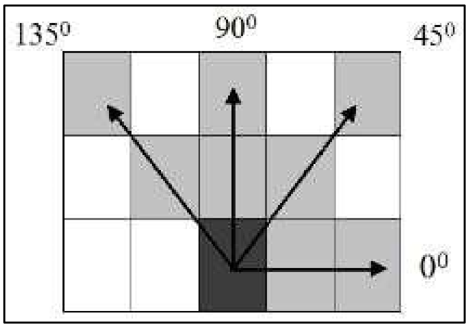

Figure 3. GLCM with angles 0°, 45°, 90°, and 135°

1. Energy
   Expresses the concentration of pair size in a matrix with a certain gray intensity.

$$Energy = \sum i, j\, p^2_{d(i,j)} \quad (1)$$

   where p(i,j) represents the value in row I and column j in the co-occurrence matrix.

2. Contrast
   Where in the form of contrast features can show the size of the spread (moment of inertia) of the image matrix elements. If it is located far from the main diagonal, the contrast value is large. Visually, the contrast value is a measure of the variation between degrees of gray in an image area.

$$f_3 = \sum_i \sum_j (i-j)^2 p_{d(i,j)} \quad (2)$$

3. Homogeneity
   Used to measure the homogeneity of image intensity variations.

$$f_4 = \sum_i \sum_j \frac{P_d(i,j)}{1+|i-j|} \quad (3)$$

4. Correlation
   The indication of a linear structure in the image shows a measure of the linear dependence of the gray degree of the image.

$$f_5 = \sum_i \sum_j \frac{ijPd(i,j) - U_x\, U_y}{\sigma_x \sigma_y} \quad (4)$$

2.4. Self Organizing Map

Self-Organizing Map (SOM) or often called a topology-preserving map is an unsupervised network method where a self-organizing process begins by selecting node weights randomly in the layer, SOM is proven to be accurate in pattern recognition, but SOM has a weakness because it requires training data that is large and high computation time [19].

The Self Organizing Map (SOM) algorithm is as follows [20]:

1. Set:
   a. Input normalized data
   b. Number of classes

2. Initialization
   a. Input weight (w_{ij}) with a random value or calculate with:

$$W_{ij} = \frac{Min\ (X_i) + Max\ (X_i)}{2} \quad (5)$$

where :

wij = weight between the jt input variable and the neurons in the i-th class.

(xi) = minimum value of the i-th input variable.

(xi) = maximum value on the i-th input variable.

a. Determine the learning rate parameter (α).
b. Specify the maximum epoch (MaxEpoch).

3. Determine Epoch = 0
4. Execute if Epoch < MaxEpoch.
   a. Epoch = Epoch + 1
   b. Random data selection, for example, the j-th selected data.
   c. Find the closest distance using the Euclidean distance formula

$$D(j) = \sum_i (W_{ij} - X_i)^2 \tag{6}$$

   d. Looking for the smallest weight as the winners. Update new weights:

$$\boldsymbol{W_{ij}}(baru) = W_{ij}(lama) + \alpha\left[X_i - W_{ij}(lama)\right] \tag{7}$$

2.5. Evaluation

Testing on the SOM method that has been made, namely testing using test data outside the dataset. In testing with test data, the input data is data from the GLCM feature extraction. In the test outside the dataset, the input image was previously pre-processed, and segmented, and GLCM feature extraction was performed. Evaluation is done by using a confusion matrix. Where this method uses the matrix table below, where if the data set consists of three classes, the first class is considered positive, the second class is considered negative, and the third class is considered neutral (Figure 6). The accuracy of the classification model can be determined by (1). Accuracy is calculated as the sum of all correct predictions divided by the total number of data sets. The best accuracy is 1.0, while the worst is 0.0. It can also be calculated with 1 – ERR [21].

$$Akurasi: \frac{TPos + TNeg + TNet}{\sum Seluruh\ Data} x\ 100\% \tag{8}$$

3. RESULTS AND ANALYSIS

The initial process of classifying the image types of Sumba woven fabrics is preprocessing the image of Sumba woven fabrics so that the image data is ready for use. The process carried out is to transform the image from a color image (RGB) into a grayscale image, then resize the image to 256 x 256. The grayscale color channel is used for segmentation in this study. Figure 5 shows an example of a preprocessed grayscale channel for each leaf image class. The data that has been entered is then segmented by using Sobel edge detection to find out the outline of the Sumba woven fabric motif. Figure 6 is an example of segmentation results in each class of Sumba woven fabric imagery.

		Observed	
		TRUE	FALSE
Predicted Class	TRUE	TRUE POSITIVE (TP)	FALSE POSITIVE (FP)
	FALSE	FALSE NEGATIVE (FN)	TRUE NEGATIVE (TN)

Figure 4. Confusion Matrix

(a) (b) (c)

Figure 5. The gray image of Sumba woven cloth; (a) ikat weaving, (b) sotis/lotis weaving, (c) songket weaving.

The results of the segmentation process are used as input data in the GLCM method for feature extraction. The feature extraction process is carried out on the segmented image which consists of four extraction features, namely contrast, correlation, energy, and homogeneity Figure 4. The results of the feature extraction process in the form of contrast, correlation, energy, and homogeneity will then be calculated using the self-organizing map method to get the class classification results. Furthermore, the results of calculations using SOM will be tested. Tests are carried out to obtain the accuracy of the method used.

(a) (b) (c)

Figure 6. Image of Sumba woven fabric segmentation; (a) ikat weaving, (b) sotis/lotis weaving, (c) songket weaving.

In this process, the image that has gone through the segmentation stage will then perform image feature extraction by calculating the average value of contrast, correlation, energy, and homogeneity. After getting the value of the feature extraction results using GLCM, the next step will be to perform calculations using SOM. At this stage, initial weights are initialized at random, after that calculations are carried out using the equality distance to calculate training data and test data and find the minimum distance. The minimum distance is used to update the weights with a Learning rate of 0.6. After carrying out the process of updating the weights, the smallest weight is declared the winner. Perform calculations until the iteration stops. calculation results can be seen in Table 1.

3.1. Implementation System

Table 1. GLCM extraction average value data.

Data To-	Contrast	Corelation	Energy	Homogeneity
1	0,108951	0,202633	0,766453	0,945525
2	0,0992575	0,210726	0,784927	0,950371
3	0,108751	0,2018	0,766991	0,945625
4	0,0998962	0,214116	0,783063	0,950052
5	0,0699396	0,264613	0,839873	0,96503
:	:	:	:	:
100	0,113888	0,211759	0,754673	0,943056

Table 2. Classification Calculation Results.

No.	Data To	Class	Type
1	1	Class 2	Tenun Sotis / Lotis
2	2	Class 2	Tenun Sotis / Lotis
3	3	Class 2	Tenun Sotis / Lotis
4	4	Class 2	Tenun Sotis / Lotis
5	5	Class 3	Tenun Songket
:	:	:	:
100	100	Class 2	Tenun Sotis / Lotis

The model interface is a media liaison between the system and the user. System operation will start on this system interface page, making it easier for users to use this application, here is the interface display for the Digital Image Processing system for Detecting the Contour of Sumba Woven Fabrics Using GLCM and SOM which is stated in Figure 8.

In Figure 7, the button “Data Latih” on the system will perform image feature extraction of the training data and will calculate the average value of contrast, correlation, energy, and homogeneity of each training data provided. On the button “Cari Citra Tenun” is the location for taking the image that will appear to be selected as the image to be classified. The preprocess button will display the results of the change from a color image to a grayscale image, then after changing the color in the preprocessing it will also resize, namely reducing the image resolution of the woven fabric image to 256 x 256. The segmentation button will display the change from a 256 x 256 grayscale image to a binary image by detecting the edges of the woven fabric motif using Sobel edge detection. The GLCM feature extraction button displays the results of feature extraction carried out by the system to obtain the average contrast, correlation, energy, and homogeneity values of the segmented image. The classification display will display the results of the classification of woven fabrics by matching the test data and training data, and also displays the estimated time used by the system to classify the types of woven fabrics.

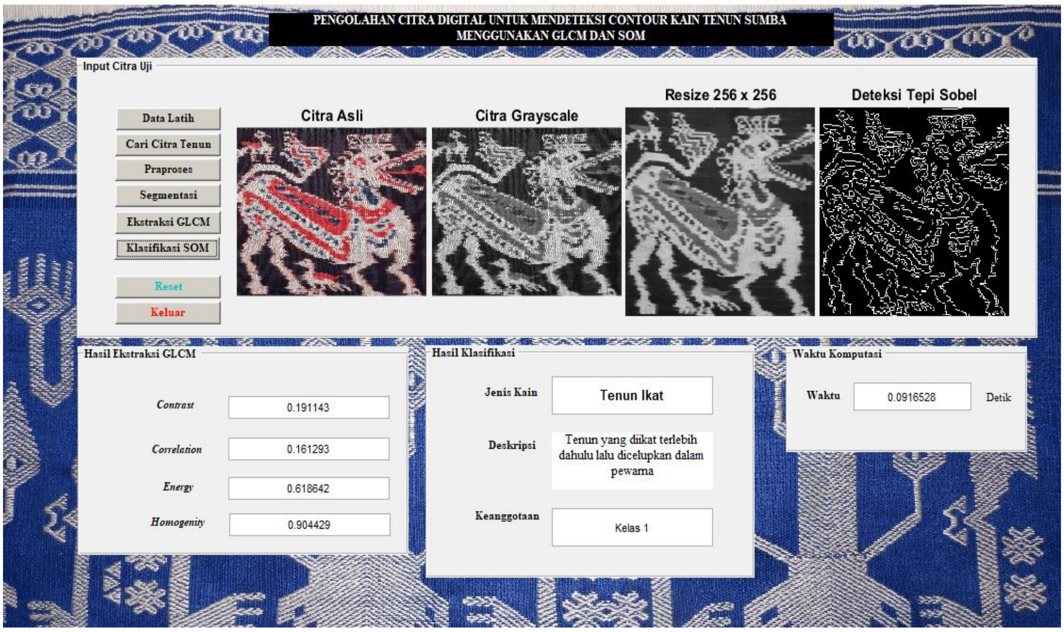

Figure 7. Classification Form

3.2. Implementation of the Self Organizing Maps network Plot

The results of the processing of the Self-organizing Map (SOM) algorithm in Matlab have several plots to display the final results, namely SOM Topology, SOM Neighbor Connection, SOM Neighbor Distance, SOM Form Input, SOM Sample Hits, SOM Weight Position of the cluster formed as shown in the figure below this**.** In Figure 8, the net plots the input vectors as green dots and shows how the SOM classifies the input space by showing a red dot for each neuron vector and connecting neighboring neurons with a blue line.

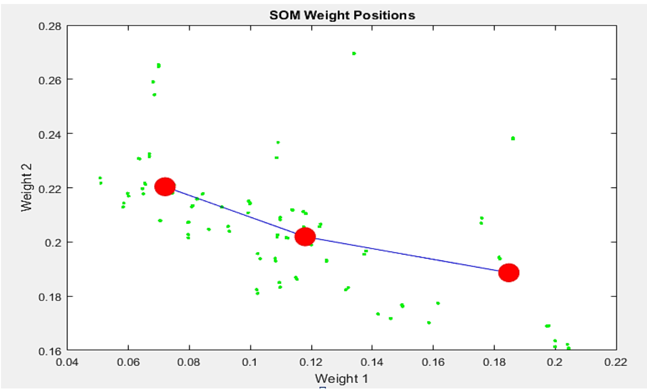

Figure 8. SOM Weight posisions

3.3. System Testing

The test is conducted to test how much accuracy of the Self Organizing Map is in classifying classes using K-Fold Cross Validation with K = 5. The sample data used is 100 data and will be divided randomly into 5 parts, each fold contains 20 data. Then the calculation process will be carried out to be able to compare the accuracy and error rate of the Self Organizing Map method. Based on the evaluation results the confusion matrix is divided into 5-fold cross-validation by calculating the values of accuracy, precision, sensitivity, and specificity. The test can be seen in 4.

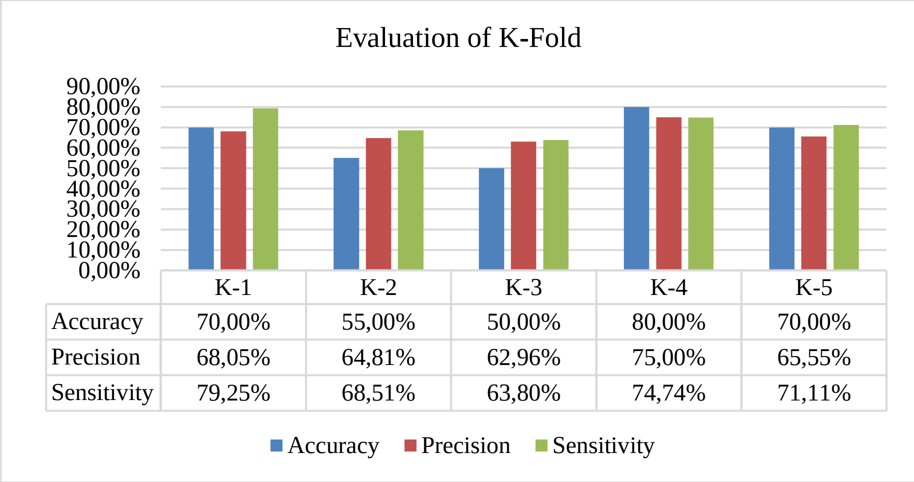

Figure 9. Graph of k-fold evaluation calculation results

The prediction results using the training data images are stated in 5. The ikat images were successfully predicted to be correct as many as 22 images and 8 images were predicted to be wrong. 35 images of Sotis/Lotis weaving were successfully predicted, while 5 images could not be predicted correctly. Songket weaving images as many as 23 images were successfully predicted, while 7 images could not be predicted correctly.

Table 3. fold validation-4 (fold 4)

		Prediction Class		
		Class 1	Class 2	Class 3
Actual Class	Class 1	3	0	0
	Class 2	0	10	1
	Class 3	3	0	3

$$\text{Accuracy} = \frac{3+10+3}{20} x\ 100 = 80\%$$

$$Precission = \frac{3}{3+0+3} + \frac{10}{0+10+0} + \frac{3}{0+1+3} / \ 3\ x\ 100 = 75\ \%$$

$$Sensitivity = \frac{3}{3+0+0} + \frac{10}{0+10+1} + \frac{3}{3+0+3} / \ 3\ x\ 100 = 74{,}74747\ \%$$

$$Specificity = \frac{1+3}{20} x\ 100 = 20\ \%$$

$$\text{Laju } Error = \frac{1+3}{20} x\ 100 = 20\ \%$$

From Figure 8 below, it can be seen that the lowest accusation result is in the 3rd fold, which is 50% and the highest accuracy is in the 4th fold, which is 80%. The lowest sensitivity results in the 3rd fold are 63.80952% and the highest is in the 4th fold, which is 74.74747%.

Table 4. Prediction results of Sumba woven fabric image.

Class	Number of Images	Correct Prediction	Wrong Prediction
Tenun Ikat	30	22	8
Tenun Sotis/Lotis	40	35	5
Tenun Songket	30	23	7

Based on program testing, it can be concluded that the program was successful in classifying Sumba woven fabrics into ikat weaving, lotis/sites weaving and songket weaving classes by achieving an accuracy rate of 80%.

4. CONCLUSION

Based on the results of this research, it can be said that the detection of the contours of Sumba woven fabrics by segmenting the edges using Sobel and extracting features using GLCM by finding the contrast, correlation, energy, and homogeneity values and classification using the Self Organizing Map obtained validation testing accuracy of 80%. From these results, it can be said that the program succeeded in selecting the types of Sumba woven fabrics.

The results of this study are by [8] which states that Sobel detection can be applied in detecting the edges of Sumba woven fabrics. Olivio et al [8] carried out the sobel edge detection segmentation process without performing feature extraction. In this study, segmentation using Sobel edge detection and feature extraction using GLCM, and classification using SOM has an accuracy of 80% greater than [8]. From these results, the segmentation of the sole edge detection, feature extraction using GLCM, and classification with SOM can be applied to the classification of Sumba Woven Image Types.

REFERENCES

[1] Indonesia Dictionary "Weaving", 2021, [Online]. Available: https://kbbi.web.id/tenun [Accessed: Okt. 13, 2021].

[2] Lamabelawa, M.I.J., and Katemba, P., "Feature Extraction of NTT Ikat Weaving Image Based on Edge Detection", *Journal of HOAQ-Information Technology*, Vol. 4, No. 3, PP. 244-249, Mey 2015

[3] Badan Pusat Statistik Nusa Tenggara Timur "Total Population Result of 2010 Population Census by Regency/City", 2010, [Online]. Available: https://ntt.bps.go.id/statictable/2018/08/28/591/jumlah-penduduk-hasil-sensus-penduduk-1971-1980-1990-2000-dan-2010-menurut-kabupaten-kota-di-provinsi-nusa-tenggara-timur.html [Accessed: Nov. 3, 2021].

[4] Badan Pusat Statistik Nusa Tenggara Timur "Area by Island", 2020, [Online]. Available: https://ntt.bps.go.id/indicator/153/925/1/luas-daerah-menurut-pulau.html [Accessed: Nov. 09, 2021].

[5] Samadara, S., Sir, J.S., and Samadara, P.D., "Empowerment of Women Ikat Weaving Craftsmen in Prai Ijing Village, Tebar Village, City District, West Sumba Regency, East Nusa Tenggara To Improve Family Economics and Support Regional Tourism Development", *Journal of Accounting, Finance, and Auditing*, Vol. 3, No. 1, PP. 20-29, June 2018. doi : 10.32511/jaka.v2i1.261

[6] Pingge, H.D., and Haingu, R.M., " Ikat Woven Fabrics as Social Studies and Elementary School Learning Media", *Journal of Jipsindo*, Vol. 7, No. 1, PP. 22-43, Mey 2020. doi : 10.21831/jipsindo.v7i1.30845

[7] Wulandari, M. R., and Nuhamara Y. T. I., "East Sumba Tire Weaving Exploration View From Ethnomathematics", *Journal Satya Widya*, Vol. 36, No. 2, PP. 105-115, Feb. 2021

[8] Gusmao, O. D. J., and Kaesmetan, Y. R. "Classification Of Extraction Results Of Sumba Woven With Fuzzy K-Nearest Neighbor Method". *National Seminar & Scientific Conference on Information Systems, Informatics & Communication*, PP. 103-1107. 2021. Retrieved from https://publikasi.uyelindo.ac.id/index.php/semmau/article/view/222

[9] Yap, A.J. "Classification Of Woven Fabric In Timor Island Using Multi Support Vector Machine (SVM) Method". *National Seminar & Scientific Conference on Information Systems, Informatics & Communication*, PP. 763-767. 2019. Retrieved from https://publikasi.uyelindo.ac.id/index.php/semmau/article/view/176

[10] Harli, E., Fauzi, A., and Kusmanto, T. H., "Class Grouping Using Self Organizing Map Neural Network at SMK N 1 Depok", *Journal of Informatics Education and Research (JEPIN)*, Vol. 2, No. 2, PP. 90-95, 2016. doi : 10.26418/jp.v2i2.17574

[11] Andry Yunanto, Riza "Classification of Painting Styles Using Self-Organizing Maps (SOM)". *Undergraduate thesis*, Ten November Institute of Technology. 2017. [Online]. Available: https://repository.its.ac.id/44842/

[12] Irwan., Hashari, A. Y., Ihsan, H., and Zaki, A., "Use Of Self Organizing Map In Community Welfare Level Grouping". *Journal of Probability and Statistics*. Vol. 1, No. 2, PP. 57-68, 2020. doi : 10.34312/jjps.v1i2.7266

[13] Tonael, D. A., Kaesmetan, Y. R., and Lamabelawa, M. I. J. "Selection of Superior Rice Seed Features Using Deep Learning Method", *Indonesian Journal of Artificial Intelligence and Data Mining* (*IJAIDM*), Vol. 4, No. 2, PP. 78-88, Sep. 2021. doi : 10.24014/ijaidm.v4i2.13947

[14] Maliki "Digital Image Segmentation", 2021, [Online]. Available: https://repository.unikom.ac.id/63326/1/CV-4-%20Segmentasi%20Citra.pdf [Accessed: Nov. 20, 2021].

[15] Kusumawati, Y., Susanto, A., Mulyono, I.U.W., Prabowo D.P., "Classification of Kudus Batik Based on Patterns Using K-NN and GLCM," *in LPPM UMP national seminar proceedings.*, April 2020, No. 5. pp. 509-514.

[16] Gressiva., and Candra, F. "Malay Songket Motive Recognition System Using Principal Component Analysis Feature Extraction and Gray Level Co-Occurrence Matrix and Artificial Neural Networks", *Journal Jom FTEKNIK*, Vol. 5, No. 2, PP. 1-7, Des. 2018.

[17] Rizal, R.A., Gulo, S. and Della, O. "Analysis of Gray Level Co-Occurrence Matrix (GLCMI) in Recognizing Facial Expression Images", *Automatic Journal*, Vol. 3, No. 2, PP. 31-38, August 2019.

[18] Kaesmetan, Y. R., and Overbeek, M. V., "Digital Image Processing using Texture Feature Extraction of Local Seeds in Nekbaun Village with Color Moment, Gray Level Co-Occurrence Matrix, and k-Nearest Neighbor", *Jurnal Teknik Informatika*, Vol. 13, No. 2, PP. 81-88, Jan. 2022.

[19] Asri, P.P., and Wulanningrum, R. "Implementation of SOM (Self Organizing Maps) for Identification of Tomato Fruit Ripe", *JTECS: Journal of Electronic Telecommunication Systems Power Control Systems & Computers*, Vol. 1, No. 2, PP. 185-192, July 2021. doi : 10.32503/jtecs.v1i2.1747

[20] Brasilka, Y., Ernawati., dan Andreswari, D. "Besurek Batik Image Calcification Based on Texture Feature Extraction Using Self Organizing Map (SOM) Artificial Neural Networks", *Recursive journal*, Vol. 3, No. 2, PP. 132-145, Nov. 2015.
[21] Saito T, Rehmsmeier M (2015) "Precision-Recall Plots Are More Informative Than ROC Plots When Evaluating Binary Classifiers on Unbalanced Datasets". PLoS ONE 10(3): e0118432. https://doi.org/10.1371/journal.pone.0118432 [Online]. [accessed November 28, 2021]. Available at: https://classeval.wordpress.com/introduction/basic-evaluation-measures/

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