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Classification of Ulos Based on Type and Ethnic Origin Using the Support Vector Machine Method with GLCM Feature Extraction

Vina Anggriani[1]*, Kana Saputra S[2], Zulfahmi Indra[3], Susiana[4]

[1,2,3]*Ilmu Komputer, Universitas Negeri Medan*
[4]*Matematika, Universitas Negeri Medan*
Vinaanggriani81@gmail.com

Abstract

Ulos is a traditional woven fabric of the Batak tribe in Indonesia that has deep cultural and symbolic meanings usually used in various traditional ceremonies such as birth, marriage and death. This challenge is compounded by the lack of ulos introduction in the formal education curriculum and exposure to modern lifestyles. To address this issue, this research proposes the development of an accurate ulos classification system. This system combines Support Vector Machine (SVM) for classification and Gray-Level Co-occurrence Matrix (GLCM) for texture feature extraction. This approach is expected to effectively identify ulos types and the origin of Batak sub-tribes (Toba, Simalungun, Karo) based on visual and textural features, while utilizing technology to preserve and promote ulos culture. The results showed that the combination of GLCM and SVM successfully built a good ulos classification model, with the best model achieving an accuracy of 92.72% and F1-Score of 92.57%, indicating the model's excellent ability to detect ulos. The website system built for ulos classification uses local deployment. Suggestions for further development include the implementation of remote deployment for wider access and the addition of more diverse ulos patterns into the dataset.

***Keywords**: Ulos, Support Vector Machine* (SVM), *Gray-Level Co-occurrence Matrix (GLCM), accuracy, website*

1. Introduction

Indonesia is one of the largest archipelagic countries in the world. It boasts an abundant cultural diversity encompassing natural diversity, ethnicity, culture, and religious beliefs. Each tribe has its own regional language and customs, each with its own unique and inseparable values. According to Batak beliefs, there are three sources of warmth for humans: the sun, fire, and ulos (a traditional cloth) [1].

Ulos is a traditional woven fabric that holds significant significance in the culture of the Batak people of Indonesia. Ulos wasn't immediately sacred upon its inception. In accordance with the laws of nature, ulos underwent a lengthy and time-consuming process before finally becoming one of the traditional symbols of the Batak people as it is today. Unlike the sacred ulos we know, in the past, ulos was even used as a blanket or sleeping mat by Batak ancestors. Today, ulos plays a very important role for the Batak people. Ulos is not only used for clothing but also in several rituals and ceremonies such as births, deaths, and weddings [2].

Ulos plays a symbolic role in various traditional ceremonies, such as weddings and funerals. There are various types of ulos with distinct motifs and colors that reflect the identity of Batak sub-tribes, such as the Toba, Karo, and Simalungun [3]. Ulos is a cultural product from North Sumatra produced through a traditional weaving process, following a manually drawn ulos pattern [4]. Ulos symbolizes blessings, compassion, and unity, in accordance with the Batak traditional philosophy of Ijuk Pangihot Ni Hodong, which means if ijuk binds the leaf stalk to the stem, then ulos binds the feeling of compassion between people [2].

The limited knowledge of the community about ulos, particularly regarding its function, region of origin, and use in certain traditional ceremonies, reflects the challenges in preserving one of Indonesia's cultural heritages. Ulos is a traditional cloth unique to the Batak people that not only serves as a garment to cover the body but also carries deep symbolic meaning. Ulos is used in various traditional ceremonies such as weddings, births, funerals, and other customary events, and each type of ulos has a philosophy related to life values, social status, and relationships among individuals within the community [2]. However, knowledge about ulos is often limited to the older generation or those closely connected to Batak traditions. The younger Batak generation living in urban areas or outside their native regions often lacks an understanding of the philosophical meaning of ulos, especially the differences between types of ulos and their use. This impacts the increasingly eroded understanding of the cultural value of ulos in daily life. Ulos is often not introduced in the formal education curriculum, so children and teenagers do not receive sufficient information about this cultural heritage [5]. Young Batak generations living in urban areas or migrating outside their region tend to be more exposed to modern lifestyles that have minimal connection with traditional customs.

As a result, their relationship with ancestral culture, including ulos, becomes increasingly distant. In many cases, ulos is only considered a traditional cloth without understanding its deeper meaning. Efforts to promote ulos as part of Batak cultural heritage are often limited to traditional events or specific activities known only within the Batak community. This causes the general public, and even some members of the Batak community themselves, to be less familiar with ulos comprehensively. This can cause ulos to lose its cultural value and be seen merely as an ordinary textile product [6]. Ulos holds very deep symbolic meaning in Batak customs, where each type of ulos has different functions and contexts of use. Some types of ulos are used for joyous occasions, such as weddings or births, while others are used for mourning (grief or death). However, with the passage of time and the wider spread of Batak culture, mistakes in the use of ulos often occur, such as using ulos sibolang (which signifies mourning) at a wedding ceremony that should use ulos sadum or ulos ragi hidup.

SVM is a learning system that utilizes a hypothesis space in the form of linear functions in a high-dimensional feature space, which is trained using a learning algorithm based on optimization theory by applying learning bias from statistical learning theory [7]. Gray-Level Co-occurrence Matrix (GLCM) is a statistical method used to measure texture in images by analyzing the spatial relationship between pairs of pixels that have certain intensity values. This method produces a matrix that records the frequency of occurrence of pixel pairs at certain distances and orientations, so it is able to describe patterns or textures in images. The main characteristics taken from GLCM include contrast, energy, homogeneity, and correlation, which are useful for describing the surface texture of objects in images [8].

In previous studies, the Support Vector Machine (SVM) method has been used for fabric texture classification by utilizing features extracted using GLCM. For example, research by [8] mengevaluasi ekstraksi fitur GLCM dan Local Binary Pattern (LBP) menggunakan multikernel SVM untuk klasifikasi batik and obtained 100% accuracy on polynomial, linear, and gaussian kernels with GLCM distances of 1, 3, and 5. In addition, research conducted by Arlinta et al.,Verifikasi Kualitas Gambar dengan Algoritma Support Vector Machine (SVM) untuk Studi Kasus Ulos Batak Toba obtained 70% accuracy. Meanwhile, research by [3] entitled Classification of Ulos Batak Toba Using Naive Bayes Classifier and Haralick obtained 83.5% accuracy.

The solution offered in this research is to develop a more accurate ulos classification system by combining these two methods, namely using Support Vector Machine for visual feature extraction and GLCM for analyzing fabric texture. With this approach, it is hoped that the system can effectively identify the type of ulos and the origin of the Toba, Simalungun, and Karo Batak tribes based on visual and textural characteristics, as well as introduce technology to preserve and promote ulos culture among the community.

2. Research Method

The following is a description of the research steps carried out by the researcher in Figure 1 :

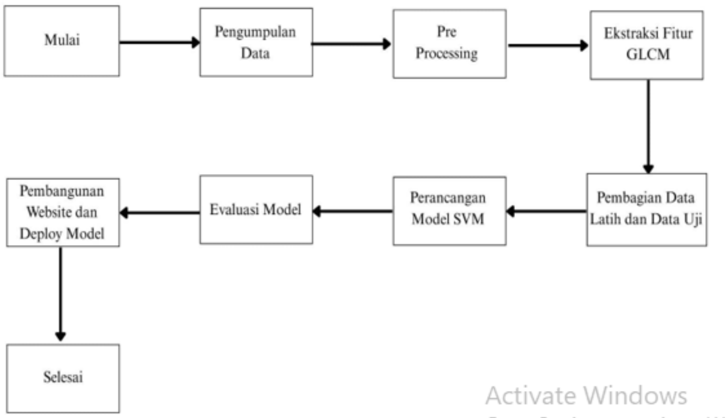

Fig. 1: Research Flow Diagram

2.1. Data collection

Data collection in this study involved collecting images of ulos cloth from the Toba, Simalungun, and Karo Batak tribes, according to their use in joyous and mournful occasions. The collected images were labeled based on their ethnicity and use. The data collection process was carried out using a smartphone camera by following the provisions set out in the research method chapter. In this study, a total of 550 image data were used, with 50 per image class. The image data were divided into 11 classes, namely mangiring, sadum, sibolang, ragihidup, jongkit (joy), nipes/gara (joy), jongkit (sorrow), nipes/gara (sorrow), ragipane (joy), ragipane (sorrow), and bukan ulos.

(a) (b) (c) (d) (e) (f) (g)

(h) (i) (j) (k)

Fig. 2: data labelling (a) ulos ragi pane (joy), (b) ulos ragi pane (sorrow), (c) ulos jongkit (sorrow), (d) ulos jongkit (joy), (e) ulos nipes/gara (sorrow), (f) ulos nipes/gara (joy), (g) ulos mangiring, (h) ulos sadum, (i) ulos ragi hidup, (j) ulos sibolang, (k) not ulos

2.2 Data pre-processing

After successfully collecting the data, the next step is data preprocessing. The preprocessing steps include converting the images to grayscale and extracting features using GLCM. For image conversion, the researchers used the scikit-image rgb2gray library. After successful conversion, the converted images were then fed into a function to extract features using GLCM. Feature extraction was performed using the scikit-image graycomatrix and graycoprops libraries. Here is an image that has been converted to grayscale :

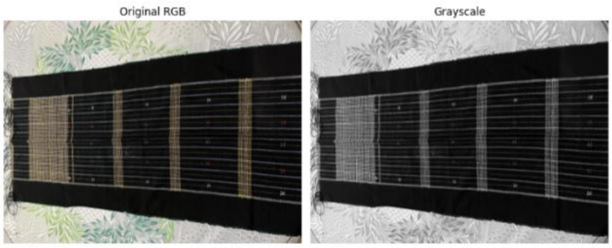

Fig.3 : Color Image Conversion Results (RGB) to Grayscale

2.3 GLCM Feature Extraction

Texture Feature Extraction using GLCM is used to analyze the texture patterns of ulos cloth based on the spatial relationships between pixels. The GLCM extraction results will be added as additional features to the model to help identify the distinctive texture patterns of each class and their uses. Looking for Contrast, Dissimilarity, and Energy/ASM. Following are the results for Contrast, Dissimilarity, and Energy/ASM :

A	B	C	D
contrast	dissimilarity	ASM	energy
216.1935623	7.579081864	0.003088845726	0.05556626042
255.1218231	8.241822978	0.002473503691	0.04972322856
243.9315467	8.318819509	0.002829315944	0.05318152933
256.3245387	8.722342983	0.002811545005	0.05301456061
378.3027582	10.0003888	0.002187104664	0.04675564018
306.1735354	9.19837544	0.002331211381	0.0482718582
203.5422025	7.915068305	0.002162856774	0.04649369154
212.9537098	7.895554483	0.002445837998	0.04944357134
266.8203612	8.904080458	0.002442340555	0.04940964912
276.2959008	8.156463787	0.002261430469	0.04753912478
353.3473505	9.574739771	0.002410732581	0.04908921618
318.5745222	9.247952702	0.003344427315	0.05782343535
324.7651089	9.436490666	0.003729029005	0.06105957733
289.4268254	8.680048307	0.004711231707	0.06863364933

Fig. 4: Feature Extraction and Image Labeling Results

2.4 Model Development

After preprocessing the data, the next step is to train the SVM model. The SVM model is built using the scikit-learn SVC (Support Vector Classifier) library. The model was built using three variations of data division (test data: training data): 70:30, 80:20, 90:10. The results of the SVM model training can be seen in Table 1.

Table 1. SVM Model Training Results Based on Data Sharing Ratio

No.	Model Training Results	
	Ratio	Accuracy
1.	70 : 30	90.30%

2.	80 : 20	92, 72%
3.	90 : 10	92,72%

2.5 Model Testing and Evaluation

The next stage after model development is model testing and evaluation to determine the most suitable model to be implemented on the website. The evaluation was conducted by observing the accuracy, precision, recall, and F1-score scores of each model. Table 2 lists the respective scores for each pre-trained model :

Table 2. Training results accuracy, precision, recall and F1-Score

Rasio	Akurasi	*Precision*	*Recall*	*F1-Score*
70 : 30	90.30%	90.90%	90.30%	90%
80:20	92.72%	93.76%	92.72%	92.44%
90 :10	92.72%	94.83%	92.72%	92.57%

Based on the data in Table 2, it can be concluded that the model with a 90:10 ratio is the best model of the three trained models. In the 90:10 model, it can be seen that the model has an accuracy value of 92.72%, indicating that in general, this model is able to classify the test data correctly. The F1-Score value of 92.57% indicates a good balance of Precision and Recall values, so that overall, the model is not too biased towards a particular class. Based on the test results that show the highest accuracy reaching 92.72%, it can be concluded that the combination of GLCM and SVM is effective for ulos classification. Here is the confusion matrix of 90:10 :

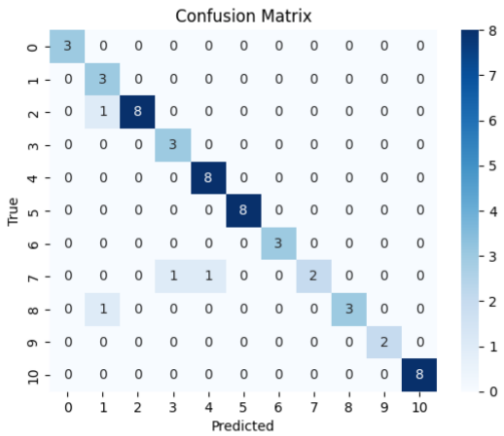

Fig. 5 : Confusion Matrix Model 90:10

2.6 Website Development and Model Implementation

The final step in this research is website development and model implementation. The model with the highest score in the next evaluation stage will be implemented into the website to be developed. The website will be a simple one that allows users to easily make model predictions without requiring specialized knowledge of machine learning. The website in this research was built using JavaScript, HTML, and CSS for the website's display (frontend) and JavaScript and Python for the server/data processing The following is the website display result :

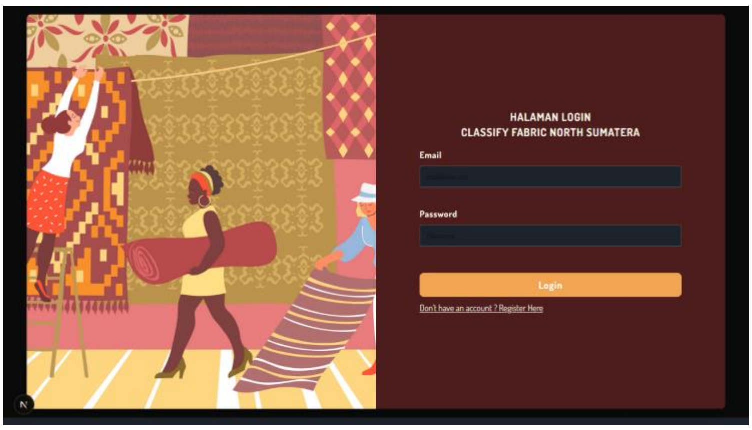

Fig. 6 : Login Page

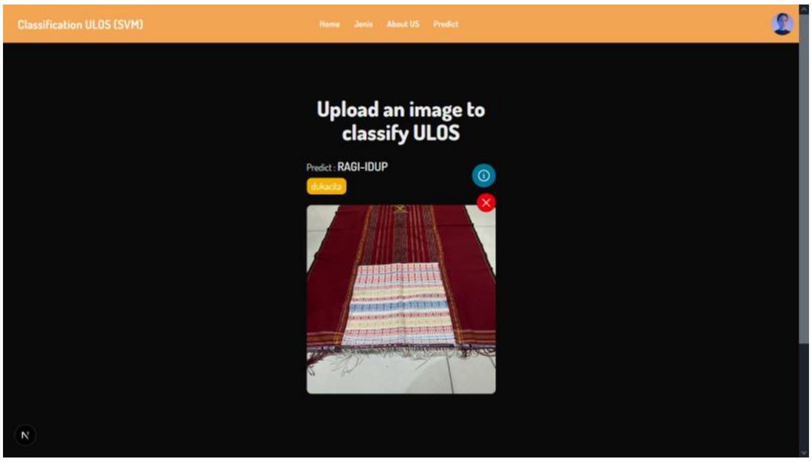

Fig. 7 : Page prediction results

3. Conclusion

Based on the results of the research that has been done, it can be concluded that the combination of the Gray-Level Co-Occurrence Matrix (GLCM) method as a feature extraction technique and Support Vector Machine (SVM) as a classification model is able to classify the types of ulos with good performance, as shown by the results of the confusion matrix obtained. This research succeeded in building an SVM model with the support of the GLCM method to recognize ulos texture patterns effectively, and implementing it into a web-based application that can classify ulos through a local server. From testing the three models tested, the best model was obtained at a training and test data ratio of 90:10, with an accuracy level of 92.72% and an F1-Score value of 92.57%, which indicates that the developed model has excellent detection capabilities and is classified as a good fit.

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