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Mbojo Character Recognition Using Shearlet Transform and Support Vector Machine

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***Abstract*— This paper aims to preserve one of the Indonesian culture, Mbojo Character. Mbojo character recognition system will be created by utilizing pattern recognition using Optical Character Recognition (OCR) technique with Shearlet Transform method for feature extraction and Support Vector Machine (SVM) for classification. Data used in this study is the image of mbojo words that consist of 2 characters typed using bimambojo.otf font with the size of 9pts for each word and with image size of 50x50 pixels. The training data uses 150 word images which represents all of Mbojo characters where each word has 3 images with 3 different positions of character placement, such as above, in the middle, and below the image field. While the testing data uses 50 word images where each of the character placed randomly in the image. All of the data were preprocessed by using grayscaling, binarization, and centering regions methods. The implementation of centering region method makes the system able to achieve accuracy up to 90%.**

Keywords—Mbojo Characters; Shearlet Transform; Support Vector Machine; Feature extraction; Optical Character Recognition; Classification; Edge Detection

I. INTRODUCTION

Indonesia has lots of tribes and cultures, one of them is the diversity of ancient characters. However, cultural preservation has been declined as the younger generation's interest in culture is diminishing. The development of information technology could become the solution of this problem. Ancient character-related research is interesting and challenging because each region or country has a unique character. One technology that can be used in the recognition of these characters is Optical Character Recognition (OCR).

OCR is the most widely implemented technique in the field of pattern recognition. OCR has also been successfully implemented to recognize non-Latin characters such as Japanese (kana) and Indian (telugu) characters. In a research about Japanese character conducted by Budiwati et. al. using Neural Network Backpropagation method in their classification step. This research achieved a maximum accuracy of 91.88% [1]. Meanwhile, a research on Indian characters using the Zoning method on feature extraction and Nearest Neighborhood Classifier (NNC) on classification have an accuracy level of 78% [2].

The recognition of ancient Indonesian literature has been completed by some researchers but still limited to only a few regions, for example, a research has been conducted by Romulus et al in 2015 related to recognition of Toba Batak script that used Hus Seven Moment Invariant for feature extraction and K-Nearest Neighbors on the classification phase. The accuracy of recognition of the Batak character is 96% [3]. Furthermore, the recognition of Balinese character examined by applying NPW (Neighborhood Pixels Weights) to the Kirsch feature combined with the HoG (Histogram of Gradient) feature and the Zoning method. The results showed that the accuracy of the recognition of Balinese character reached 85% [4].

In 2017, Areni, I.S. et.al. did Lontara recognition by combining two methods of extraction feature that is Modified Direction Feature (MDF) and Fourier Descriptor (FD) in feature extraction to increase the accuracy level. The method used in the classification phase is Multi Class Support Vector Machine (MC-SVM). The result of the study was 96% [5].

The recognition of ancient Indonesian literatures that had been finished by these researchers encourage authors' to conduct related research to preserve the culture of Indonesia, the Mbojo script originating from Bima, Nusa Tenggara Barat. The language of Bima or nggahi mbojo is the Malayo-Polynesian language spoken in the eastern part of Sumbawa Island in Indonesia and is used by approximately 500.000 people [6]. The Mbojo script was used from the 14th century until Islam entered Bima in the 17th century and the Bima community began to use Arab-Malay.

The research about Mbojo character never been done before. So in this research, the recognition of Mbojo script is done by Shearlet transform at feature extraction based on a research conducted by Meshkini in 2017 on texture classification with Shearlet transform on the feature extraction and K-Nearest Neighbors on the classification phase with the accuracy obtained by 99.61% [7]. While on the classification stage, this research uses SVM method.

II. PROPOSED METHOD

The recognition phase of Mbojo script consists of preprocessing, feature extraction, and classification as shown in Fig.1.

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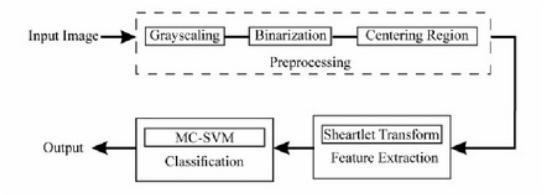

Fig.1 Flow Diagram recognition system

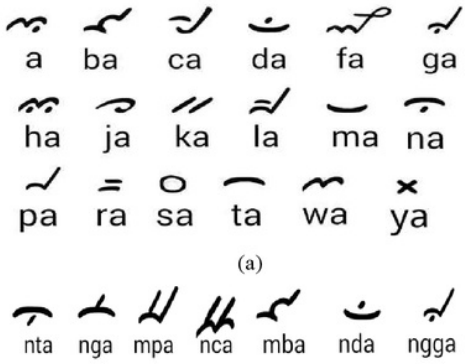

Fig. 2 Mbojo Characters : (a) letters A through Y; (b) nasal letters

A. *Data Description*

Mbojo character has two forms of letters. First, the form of letters A to Y except for Q, V, X, and Z are not found in the form of letters [8], for consonants Q replaced by K, V replaced by F, Z replaced by J and bimanese has no words which use consonant X. Second, the form of nasal letters, i.e. mba, nca, nga, ngga, nda, nta and mpa. Fig.2 shows two forms of mbojo characters [6].

Each of the Mbojo characters has an inherent vowel that is /a/. To change the vowels to /i/, /u/, /e/ and /o/ in each letter requires additional punctuation. Fig.3 shows punctuation with example of letter A [6].

In addition, there are some additional punctuations that are usually used to write absorption words. Virama is used to remove vowels from letters. Gemination is used to double the consonant on the letter for repeat the word. Fig.4 shows forms and examples of virama, gemination and repeat [6].

Furthermore, the process of creating data is done by making mbojo character word image which consists of 2 characters. The image dimensions are 50x50 pixels and using bimambojo.otf fonts with the size of 9pts. The training data were acquired from 150 words of mbojo character where each word has 3 different position placement forms in the image field such as above, in the middle, and below the image field. Then, the testing data were acquired 50 words of mbojo script characters positioned randomly and not the same as the training data. Fig.5 shows the sample of testing and training data with different position.

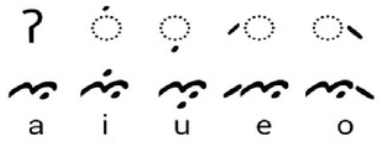

Fig. 3 Punctuation to change the vowel

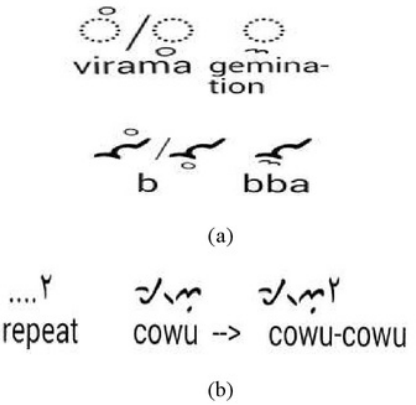

Fig. 4. a. Virama and geminition with the example. b. Repeat with the example

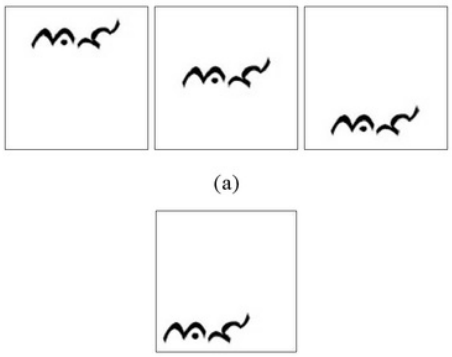

Fig.5 Examples of training and testing data use the word "A MBA" which means "MARKET" : a. training data. b.testing data

B. *Preprocessing*

Preprocessing is done to prepare the input data before entering the feature extraction step. This research uses some of the preprocessing method, i.e. grayscaling, binarization and centering region.

- *Grayscaling* is a method of converting the RGB value on the image to gray degrees based on the following equation:

$$Gray = W_r R + W_g G + W_b B \quad (1)$$

where W_r, W_g, and W_b are the weight values of RED, GREEN, BLUE colors. While R, G, and B is the color intensity of red, green, and blue, respectively.

- Binarization, which converts a matrix pixel into a logical matrix by setting a threshold value between 0 - 255 to set the pixel value from 0 or to the value of 1. The binary equation follows:

$$f(x,y) = \begin{cases} 1 \; if \; f(x,y) \leq T \\ 0 \; if \; f(x,y) > T \end{cases} \quad (2)$$

In eq. (2), $f(x,y)$ is the grayscale image and T is the threshold value. The used threshold value is 210 in this study.

- Centering region is the process of moving the word position to the midpoint of the image. By searching the central coordinates of the word region of the image, then look for the row and column differences between the center of the word. The image center is determined using the following equation:

$$M_x = (\frac{Lf_x}{2} - C_x)$$
$$M_y = (\frac{Lf_y}{2} - C_y) \quad (3)$$

where Lf is the image dimension and C is the central coordinate of the image region as shown in Fig.6. The moving object is based on the M_x and M_y values. The illustration of the shifting region is shown in Fig.6.

After the centering region, the binary image pixel changes to the value of 0 and 255 by multiplying all elements with 255.

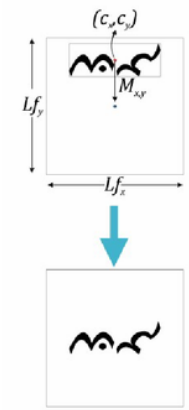

Fig.6 Shifting the region to the center of the image

C. Feature Extraction

At the feature extraction, shearlet transform method applied. Shearlets are a multi-scale framework that allows efficient encoding of an isotropic features in multivariate problem classes [9]. The shearlet transform is different from the wavelet transform because it has the ability to detect directionality [10].

The process of feature extraction can be divided into two parts:

- Process to form a complex shearlet system
- Process of edge detection

On the first process, computation of complex shearlet system is done with various input arguments such as size row image, size column image, wavelet effective support, Gaussian effective support, scales per octave, shear level, alpha, octaves, and scales. Fig.7 shows the flowchart of complex shearlet system.

- On the get continue shearlet phase, output of matrix from multiplication of wavelet frequency and Gaussian frequency will be obtained.
- After that perform the 2-D Invers Fast Fourier transform process.
- Perform the Hilbert process with several conditions.
  Condition1:shearlet=Hilbert(-shearlet) ;
  shearlet=circsift(shearlet,[1 0])
  Condition2 :shearlet=((Hilbert(-shearlet)')');
  shearlet=circsift(shearlet,[0 1])
  Condition3 :shearlet=((Hilbert(-shearlet)')');
- Perform the 2-D Fast Fourier transform.
- Store the shearlet value on a 3D matrix.

After complex shearlet system obtained, the next phase is edge detection. This phase started with inserting the image, complex shearlet system, minimal contrast, and offset. Fig.8 shows the flowchart from edge detection.

- Gained coefficient by multiplying image with complex shearlet system.
- Perform element shift on coefficient with several conditions.
  Condition 1= sift(-coefficient(:,:,ori,:),[-1,0,0,0])
  Condition 2= sift(-coefficient(:,:,ori,:),[0,1,0,0])
  Condition 3= sift(-coefficient(:,:,ori,:),[0,-1,0,0])
- Calculate CI (coefficient image) and CR (coefficient real).
- Calculate CiPivot and MaxPivot
- Calculate pivotoris(pivot orientation) and pivotscales
- Obtain the edge orientation

After the feature value is obtained, then reshape the image dimension to matrix 1xn, where n is the result of image dimension multiplication.

D. Classification

This research uses MC-SVM method for the classification phase. The basis of SVM begins with the classification problem of two classes that belong to a linear problem. SVM tries to find the best hyperplane on the input space to separate the two classes.

In a multi-class classification, an output can be more than one class and must be divided into exclusive M classes. Several methods for solving multi-class problems are Directed Acyclic Graph (DAG), Binary Tree (BT), One-Against-One (OAO) and One-Against-All (OAA) classifier.

This study uses multi-class SVM to classify each feature value by one-against-one method so that the separation function of two classes can be determined.

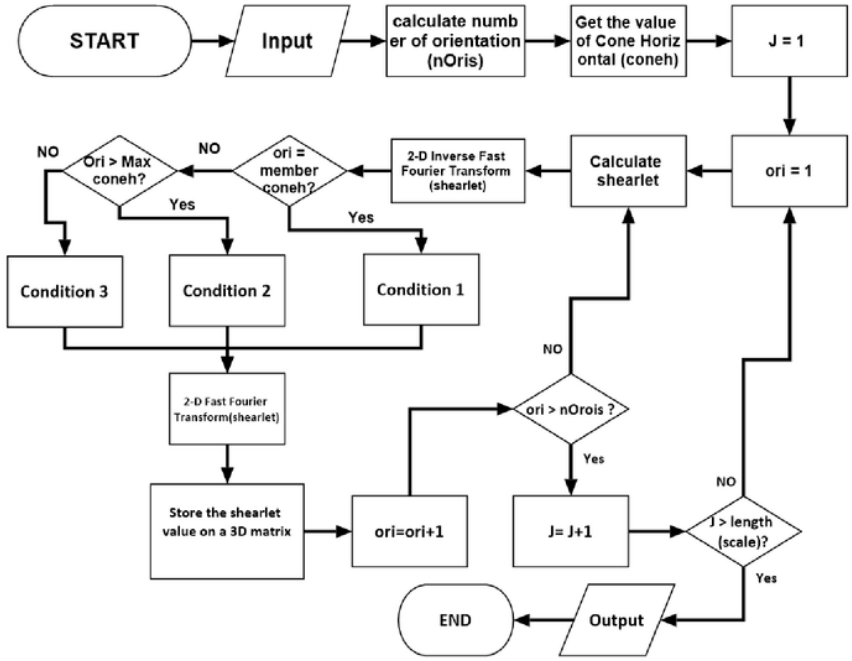

Fig.7. flowchart complex shearlet system

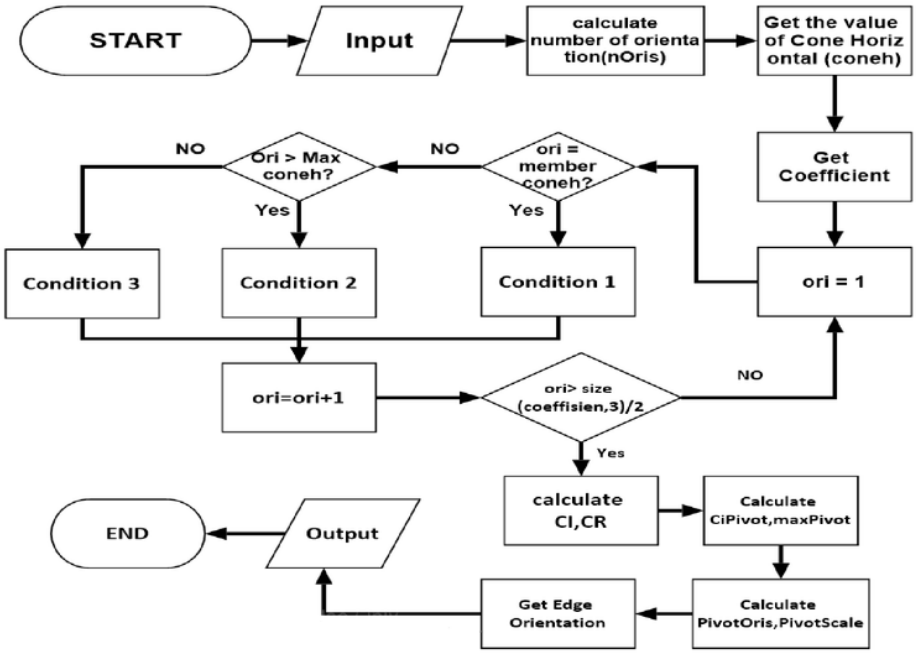

Fig.8 Flowchart edge detection

E. System Performance

The last step is to calculate the prediction accuracy (P_A) of the recognition system by the eq. (4).

$$P_A = (P_T / D_T) \times 100 \quad (4)$$

where P_T is the correct number of predictions and D_T is the total amount of data.

III. Results and Discussion

In the testing phase, the number of the testing data is 50, where some of them are also available in the training data but with different positions in the image field.

In the preprocessing stage, comparison of recognition process is completed by adding centering region method. A recognition system that adds a centering region method can increase the system's accuracy. By using 50 data tested, the system is able to recognize 45 data and failed to recognize 5 data. The accuration system is 90% based on the recognition result. Wrong words recognition can be seen in Table.I and Correct words recognition can be seen in Table II

Prediction errors are caused by the wrong edge detection from a combination of letters and punctuation. For further research, the recognition accuracy will be improved by adding methods on preprocessing or combining some methods of features extraction.

TABLE I. TABLE OF WRONG WORD RECOGNITION

No.	Mbojo word	Spelling	Predict	Spelling
1		**bona**		**mbako**
2		**boru**		**kontu**
3		**kohi**		**koro**
4		**lowi**		**wante**
5		**nari**		**naru**

TABLE II. TABLE OF CORRECT WORD RECOGNITION

No.	Mbojo word	Spelling	Predict	Spelling
1		amba		amba
2		ampe		ampe
3		awu		awu
4		Bau		bau
5		Bou		bou
6		bune		bune
7		bura		bura
8		caha		caha
9		caru		caru
10		Cili		cili
11		fiki		fiki
12		fiko		fiko
13		haba		haba
14		haju		haju
15		haka		haka
16		hampu		hampu
17		inca		inca
18		Iwa		iwa
19		Iyo		iyo
20		jagu		jagu

IV. Conclusions

The process of feature extraction with shearlet transform and classification with SVM has been completed in Mbojo script recognition system with the image input. The total data used in the training data is 450 consists of 150 words for each three different positions. Total data analyzed were 50 data with a different position from the training data. The results shows that the rate of recognition system reaches 90% accuracy.

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