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**Research Article** 

# Fourier Descriptor on Lontara Scripts Handwriting Recognition

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**Abstract**

The critical thing in the pattern recognition process is feature extraction. It is a method to get the characteristics of an image (image) so that it can be recognized by one another. In this study, the Fourier descriptor method was used to extract the Lontara script pattern consisting of 23 letters. The Fourier descriptor is a method used in object recognition and image processing to represent an image's shape of segment boundaries. Character recognition is done using Euclidean and Manhattan distances. The test results show that the highest recognition rate reaches 91.30% accuracy using a Fourier coefficient of 50. Letter recognition using Manhattan and Euclidean tends to be the same or produces accuracy that tends to be similar. The highest accuracy is achieved when using Manhattan at 91.30%.

**Keywords:** Fourier Descriptor; Lontara; Euclidean; Manhattan; Pattern Recognition.

## Introduction

Indonesia is a country that is recognizable for its rich cultural heritage, such as traditional languages. There are more than 700 regional languages and dialects throughout Indonesia. In South Sulawesi, the Bugis Tribe people have a regional spoken language still used for speaking and communicating. Besides the regional language, the Bugis Tribe has a traditional script, namely the Lontara script.

Lontara script consists of 23 letters. It is called Lontara script, since it was initially written on Lontar (Borassus flabellifer Linn) leaves. Another mention of Lontara is *sulapaq eppaq wola suji* script which means quadrangle rhombus as its rectangular shape resembles a rhombus[1]. The Lontara scripts are shown in **Figure 1**. The lontara script has a significant role in the Bugis community. Long ago, it was used to communicate and write the advice of the Bugis ancestors. One of the ancient manuscripts left by the ancestors of the Bugis community written in Lontara script is I La Galigo. La Galigo is an essential literary work since it contains the historical mythology of the Bugis people in South Sulawesi.

There are fewer and fewer people who can write and read Lontara scripts [2][3]. If so, future generations will no longer be able to recognize and read Lontara writings and even read the ancient Bugis script written in Lontara letters.

Therefore, it is necessary efforts to preserve, study, and introduce Lontara Script, by taking an approach based on artificial intelligence technology. One form uses technology such as pattern recognition to recognize patterns and understand the Lontara script.

Pattern recognition of an object is a classification based on the main characteristics of the object[4]. It can be applied for face recognition[5], handwritten image recognition to be converted to Latin letters[6],[7], and fingerprint pattern recognition for owner identification [8],[9].

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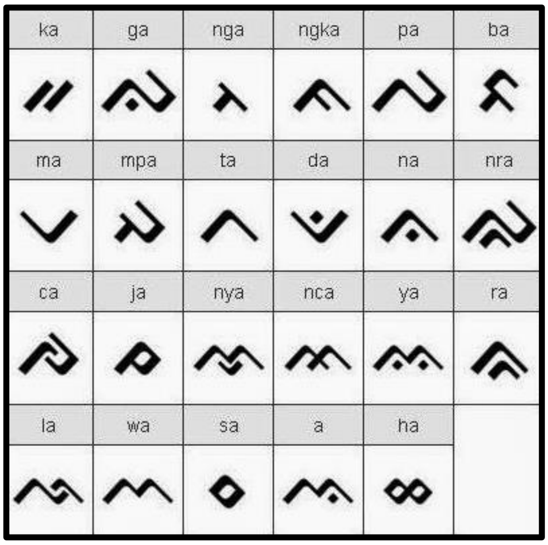



**Figure 1**. Lontara Scripts

In image pattern recognition, feature extraction is essential to carry out before the recognition process. Feature extraction is a method to obtain the characteristics of an image that can be easily recognized or classified. Feature extraction on image recognition can be categorized as shape and texture patterns. Sethi's research [7] used Principal Component Analysis (PCA) to extract number image patterns. At the same time, Huq [6] extracted Bangla handwriting patterns using the combination of Zernike Moment, Binary Pixel, and Histogram of Oriented Gradients.

As for this study, the Fourier descriptor method was used to extract the pattern of the Lontara script consisting of 23 letters. The Fourier descriptor is a method used in object recognition and image processing to represent an image's shape of segment boundaries. The advantage of the Fourier descriptor is that it does not depend on translation, rotation, and scaling [10][11][12]. This method has been used in Ghotkar's research[10] to recognize Indian Sign Language letters. With various conditions, such as lighting, skin color, and camera distance, letters can be recognized with an accuracy of 76%. The research aims to analyze the effect of the Fourier Descriptor in recognition of the Lontara Script by using Euclidean and Manhattan distance functions.

## Method

This research proposes Fourier Descriptor that is used to perform feature extraction. Fourier Descriptor is selected as it is invariant of image tranformation. In recognition of the Lontara Script images, the following steps are hereby introduced.

### A. Data Collection

The data used is handwritten image data of the Lontara script. The lontara script is handwritten using a black marker on white paper. Then the scanned image is then carried out by cropping and resizing the image to 309 x 300 pixels for each letter in the training data. In the training data, 23 letters were carried out by Fourier transformation to extract features with five coefficients each, namely coefficients 2, 10, 25, and 50. Ninety-two image data were used as test data to be recognized using Euclidean Distance and Manhattan distance.

### B. Image Pre Processing

In this research, the Fourier descriptor was used to extract the image features of the Lontara script. Before performing feature extraction, preprocessing is carried out. Preprocessing aims to improve data to be ready to be processed and accessible in the computational process. The preprocessing used is converting RGB images to grayscale and then converted into binary images. This image conversion results in an image with only black or white color. Afterward, dilation and erosion are carried out. Dilation and erosion are morphological image operations that smooth contour and eliminate small holes. Erosion helps remove noise in the image because small foreground structures are eliminated, while dilation helps smooth and cover holes. Erosion followed by dilation is called an opening operation.

### C. Contour Tracking

Contour is the change in intensity from one point to its neighbors in an image. With changes in the intensity of the eye, a person can detect the edges or contours of an object. Contour detection aims to get the edges of an object. One way to detect an object's edge is by using Moore's contour tracking algorithm [13]. In Moore's Algorithm, the input is $f(x, y)$ where *x* row and *y* column of image. Get a pixel worth 1 on the left and top. The position of the pixel is recorded at $a_0$ and the position for the next pixel is recorded at $b_0$. After that check 8 neighbors clockwise starting from $a_0$. The first pixel with a value of one is recorded on $a_1$. The positions for the pixels that precede are recorded in $b_1$. Note that Contour(1) = $a_0$, contour(2) = $a_1$, sum = 2 then note that $a_1 = a_0$ and $b_1 = b_0$. The next is the looping process, Find the pixels in the 8 neighbors whose first value is 1, If it is 1 with the search starts from direction *b* using a clockwise pattern then note the position of the pixel to *a* and that precedes *a* the pixel to *b*. Add *b* as part of the contour. Looping process will stop if $a = a_0$. It will result an array containing contour pixels.

### D. Fourier Descriptor

Feature Extraction is a process step in the introduction of an object. The purpose of feature extraction is to obtain the characteristics of an object that can be used in the classification process. Feature extraction on the image can be in texture extraction and shape extraction. The feature extraction results can be in the form of contours, areas, and transformations. This study's feature extraction in contours is obtained from the Fourier descriptor.

The Fourier descriptor is a feature extraction commonly implemented in shape analysis[14][10]. The Fourier coefficients form the descriptors representing the frequency domain shape. The descriptors record each coordinate of a pixel, and a description of the shape (contour) in two dimensions is obtained.

To generate feature values, contour detection is performed. Contours that have been obtained in the form of contour pixels *f(x,y)* with has *k* pixels ranging from 0 to 1-*K* (are stored ) arranged in complex number as written in (1) :

$$s(k) = x_k(k) + I\,y(k) \tag{1}$$

where $x(k) = x_k$ real and $I\,y(k) = Ik_k$ imaginary numbers. The value of the Fourier descriptor for $u = 0,1,\ldots,K-1$ is then obtained by the equation:

$$a(u) = \frac{1}{k}\sum_{k=0}^{K-1} s(k).e^{\left[-j\frac{2\pi uk}{K}\right]} \tag{2}$$

*s(k)* $k = 0,1,\ldots,K-1$ can be restored using inverse of Fourier Transform using the following equation :

$$s(k) = \sum_{u=0}^{K-1} a(u).e^{\left[-j\frac{2\pi ui}{K}\right]} \tag{3}$$

### E. Normalization

Furthermore, to have an invariant Fourier descriptor for translation, rotation, and scale, it is necessary to do normalization. The first coefficient is used to normalize all of the coefficients by dividing derived from the equation:

$$s(k) = \left|\frac{a_k}{a_0}\right|, k = 0,1,\ldots N-1 \tag{4}$$

The magnitude of the first coefficient $a_0$ is used as shape descriptor known as Fourier descriptor and coefficient value after normalization is ultimately considered as value of extracted shape feature.

### F. Scripts Recognition

Euclidean and Manhattan distances are preferred to classify every script in this research. Euclidean distance compares the results of test data feature extraction with training data stored in the database[15]. The results of this distance function search for the minimum distance of feature extraction value of the test and the training data. The euclidean distance is given by the formula given below :

$$d(x,y) = |x-y| = \sqrt{\sum_{i}^{n}(x_i - y_i)^2} \quad (5)$$

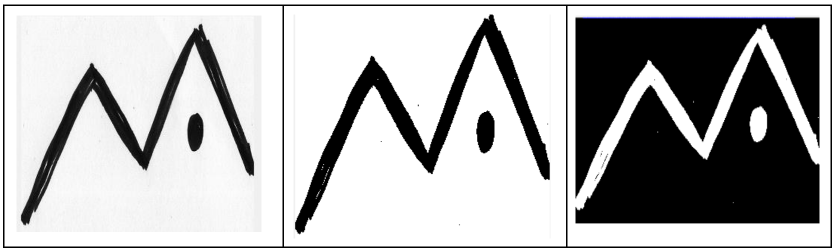
where $x$ and $y$ are the feature vector of training and test data.

Manhattan Distance calculates the absolute difference (absolute) between the coordinates of a pair of objects. The formula used is as follows:

$$d(x,y) = \sum_{i=1}^{n} |x_i - y_i| \quad (6)$$

## Results and Discussion

In the image recognition step, the initial step is to convert the training and test data to be more easily processed and extracted from the features. In this research, the image in RGB format is converted into a grayscale color space **Figure 2** and then converted into a binary image shown in **Figure 2**. To eliminate the noise of the image, a morphological process is carried out, namely the opening operation of erosion followed by dilation. An example of the Image conversion step is shown in **Figure 2**.



(a) (b) (c)

**Figure 2.** Image Preprocessing (a) Convertion from RGB to Grayscale

(b) Convertion from Grascale to Binary Image (c) Opening Operation

After image preprocessing, to extract the feature, Fourier Descriptor is applied. The Fourier coefficients are selected based on the number of desired features. If the coefficient selected is 2, then the number of features extracted is 2, and if it is selected for N, then the output will produce N features. In this study, the selected coefficients are 2, 10, 25, and 50. An example of the extraction of the Fourier Descriptor with two coefficients is shown in **Table 1**.

**Table 1**. The Extracted Feature With Coefficient 2

| Testing Data | Feature 1 | Feature 2 |
|---|---|---|
| KA | 1.0000 | 0.4482 |
| GA | 1.0000 | 0.2868 |
| NGA | 1.0000 | 0.4049 |
| NGKA | 1.0000 | 0.3010 |
| PA | 1.0000 | 0.2902 |
| BA | 1.0000 | 0.4262 |
| MA | 1.0000 | 0.3263 |

| Testing Data | Feature 1 | Feature 2 |
|---|---|---|
| MPA | 1.0000 | 0.3059 |
| TA | 1.0000 | 0.3469 |
| DA | 1.0000 | 0.1111 |
| NA | 1.0000 | 0.3390 |
| NRA | 1.0000 | 0.2580 |
| CA | 1.0000 | 0.2451 |
| JA | 1.0000 | 0.4800 |
| NYA | 1.0000 | 0.4173 |
| NCA | 1.0000 | 0.3534 |
| YA | 1.0000 | 0.3598 |
| RA | 1.0000 | 0.3800 |
| LA | 1.0000 | 0.2105 |
| WA | 1.0000 | 0.4228 |
| SA | 1.0000 | 0.6189 |
| A | 1.0000 | 0.4051 |
| HA | 1.0000 | 0.5451 |

## A. Recognition Results

In the recognition process, the training data and test data are classified using the distance method to see the similarity of the test data to all letter images in the training data. The smallest distance value indicates the value closest to the training data's similarity. In this research, the classification uses Euclidean distance and Manhattan distance. Examples of recognition results are listed in **Table 2** and **Table 3**.

**Table 2**. The Recognition Results Using Euclidean Distance With Coefficient 50

| Testing Data | Recognition | Results |
|---|---|---|
| KA | KA | TRUE |
| GA | GA | TRUE |
| NGA | NGA | TRUE |
| NGKA | NGKA | TRUE |
| PA | NRA | FALSE |
| BA | BA | TRUE |
| MA | NA | FALSE |
| MPA | MPA | TRUE |
| TA | TA | TRUE |
| DA | DA | TRUE |
| NA | NA | TRUE |
| NRA | NRA | TRUE |
| CA | CA | TRUE |
| JA | JA | TRUE |
| NYA | WA | FALSE |
| NCA | NCA | TRUE |
| YA | YA | TRUE |
| RA | RA | TRUE |
| LA | LA | TRUE |
| WA | A | FALSE |
| SA | SA | TRUE |
| A | A | TRUE |
| HA | HA | TRUE |

**Table 3**. The Recognition Results Using Manhattan Distance With Coefficient 50

| Testing Data | Recognition | Results |
|---|---|---|
| KA | KA | TRUE |
| GA | GA | TRUE |
| NGA | NGA | TRUE |
| NGKA | NGKA | TRUE |

| Testing Data | Recognition | Results |
|---|---|---|
| PA | NRA | FALSE |
| BA | BA | TRUE |
| MA | NA | FALSE |
| MPA | MPA | TRUE |
| TA | TA | TRUE |
| DA | DA | TRUE |
| NA | NA | TRUE |
| NRA | NRA | TRUE |
| CA | CA | TRUE |
| JA | JA | TRUE |
| NYA | NYA | TRUE |
| NCA | NCA | TRUE |
| YA | YA | TRUE |
| RA | RA | TRUE |
| LA | LA | TRUE |
| WA | WA | TRUE |
| SA | SA | TRUE |
| A | A | TRUE |
| HA | HA | TRUE |

The results shown in **Table 2** using Euclidean distance, 19 images are classified correctly, and 4 images are classified incorrectly. However by using Manhattan distance, 21 images are correctly classified.

### B. Accuracy Results

In the testing process, three scenarios are performed. Tests are carried out to determine whether the Fourier Descriptor is invariant for rotation, scaling, and translation. The scenario 1, the testing images used are standard images with no image transformation process applied, and the position of the image is not changed. In scenario 2, the testing images are rotated 90 and 180 degrees to the right. The last, scenario 3, the testing images are scaled with a factor of 2. All the testing images are also tested with five Fourier coefficients, coefficients 2, 10, 25, and 50, using Euclidean and Manhattan distances. The testing accuracy is given in **Table 4**, **Table 5**, and **Table 6**.

The results of script recognition based on coefficients with standards are shown in **Table 4**. It shows that coefficient 2 produces very small accuracy 39.13%, with Euclidean and Manhattan. Meanwhile, the highest accuracy reaches 91.30% by Manhattan Distance with a coefficient of 50.

The results also show that the more coefficients are used, the higher the accuracy is achieved. This occurs since Descriptor Fourier represents image shape using contour through normalization of coefficient value. The more coefficients are used, the smoother the contour obtained that represents Lontara Scripts. As a result, the classification accuracy is higher.

**Table 4**. The Recognition Accuracy With Standard Images

| Coefficient | Recognition Accuracy (%) | |
|---|---|---|
| | ***Euclidean*** | ***Manhattan*** |
| 2 | 39.13 | 39.13 |
| 10 | 82.61 | 82.61 |
| 25 | 82.61 | 82.61 |
| 50 | 86.96 | 91.30 |

**Table 5.** The Recognition Accuracy with Rotated Image (%)

| Coefficient | Rotation 90 | | Rotation 180 | |
|---|---|---|---|---|
| | ***Euclidean*** | ***Manhattan*** | ***Euclidean*** | ***Manhattan*** |
| 2 | 13.04 | 13.04 | 13.04 | 13.04 |

| Coefficient | Rotation 90 | | Rotation 180 | |
|---|---|---|---|---|
| | *Euclidean* | *Manhattan* | *Euclidean* | *Manhattan* |
| 10 | 60.87 | 65.22 | 60.87 | 52.17 |
| 25 | 60.87 | 60.87 | 60.87 | 60.87 |
| 50 | 60.87 | 60.87 | 60.87 | 60.87 |

**Table 5** shows that the test image, which has been rotated by 90 degrees, can be identified using Euclidean and Manhattan by 13.04% for coefficient 2. Coefficient 10 with Euclidean Distance produces 60.87% and Manhattan 65.22%. For coefficients of 25 and 50, both distance methods recognize the same accuracy of 60.87%. After being rotated 180 degrees, the results also show that the accuracy of coefficients 2, 25, and 50 is the same as the 90-degree rotation test using either Euclidean Distance or Manhattan Distance. The coefficient is 10, resulting in 65.22% with Euclidean and 52.17% with Manhattan Distance.

**Table 6.** The Recognition Accuracy with Scaled Image

| Coefficient | Recognition Accuracy (%) | |
|---|---|---|
| | *Euclidean* | *Manhattan* |
| 2 | 39.13 | 39.13 |
| 10 | 78.26 | 78.26 |
| 25 | 86.96 | 91.30 |
| 50 | 86.96 | 82.60 |

The test results in **Table 6** show that the highest recognition rate reaches an accuracy of 91.30% by using a Fourier coefficient of 50. Script recognition using Manhattan and Euclidean tends to be the same or produces accuracy that tends to differ slightly. The highest accuracy is achieved when using Manhattan at 91.30%.

## Conclusion

This research focuses on feature extraction using Fourier Descriptor. From The testing process results, it can be concluded that The Fourier descriptor can be used in image feature extraction to recognize the image of the lontara script. The test results show that the highest recognition rate reaches an accuracy of 91.30% by using a Fourier coefficient of 50. This occurs since Fourier Descriptor represents image shape using contour through normalization of coefficient value. The more coefficients are used, the smoother the contour obtained that represents Lontara Scripts. As a result, the classification accuracy is higher. Comparison using Euclidean and Manhattan in Lontara recognition that has been made shows that accuracy tends to be the same or similar.

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