Pattern Recognition on Herbs Leaves Using Region-Based Invariants Feature Extraction

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***Abstract*— As medicine, herbal plants have been widely used since ancient times, and are still used today. There are various types of herbal plants that can be used as medicine but due to the limited ability of communities to recognize the type of plants and the lack of information, both cause the limited use of plants as medicine. In this research, an herbal plants identification system based on leaves pattern was developed. This identification system is based on the shape of the herbal plants' leaves. Before identification, preprocessing stages should be performed such as conversion to grayscale image, conversion to binary image, and image segmentation using Otsu's method. Feature extraction method used in this system is one kind of region-based invariant feature extraction, which is well-known as Hu's seven moments invariant and the Euclidean or Canberra distance as a recognition method. The research was conducted on 15 types of herbal plants. Based on the research, the percentage of recognition in this identification system using Euclidean Distance reached 86.67% with the lowest recognition rate is 40% for *mangkokan* leaf. While using Canberra distance for recognizing, the percentage of recognition is 72% and the lowest recognition rate is 20% for *keji beling* leaf. The best recognition rate of 100% for Euclidean distance similarity measure is reached when 9 (nine) types of leaves were implemented, i.e. banyan (*beringin*), *binahong, dolar, keji-beling, laos,* noni (*mengkudu*), papaya, red betel (*sirih merah*), and soursop (*sirsak*) leaves. When Canberra distance used, 100% recognition rate was reached by 5 (five) leaves types, i.e. *binahong, dolar, pecut-kuda,* papaya, and red betel (*sirih merah*) leaves.**

Keywords—Identification System, herbal plant, leaves pattern, Hu's seven moments invariant, Euclidean distance.

I. INTRODUCTION

Herbs as medicinal products have long been used, and is still used today. The use of herbs in curing the disease is more secure because it is natural and has side effects that are minimal when compared with the use of synthetic drugs. Besides being more secure, plants can also be found easily and the price is cheaper [1].

The limited ability of communities to identify types of herbs leaves, causing limited use of plants as medicines. So many types of plants, and properties variation also cause the complication of recognition. Community knowledge was limited to plants that are generally used as herbs such as turmeric, ginger, turmeric, and others while, in fact, there are many plants that can be utilized.

In this research, we designed a system that can be used to identify the type of plant and its benefit in curing the disease. Recognition is based on the plant leaf pattern plants to be identified. The method used for image feature extraction is a method Hu's Seven Moments Invariant [2],[3]. Before extracted, a process of image segmentation uses Otsu's method [4],[5]. After the characteristics of the images are extracted, the system will match the data extraction to a database that was created earlier. Data matching is done by calculating the Euclidean or Canberra distance [6].

II. RESEARCH METHODOLOGY

A. System Design

There are 3 (three) steps on herbal plant identification system, i.e. preprocessing; data training and registration; and image recognition. These 3 (three) stages can be depicted in Fig. 1 until Fig. 3. It can be noted that in process of image segmentation Otsu's method [5] was used.

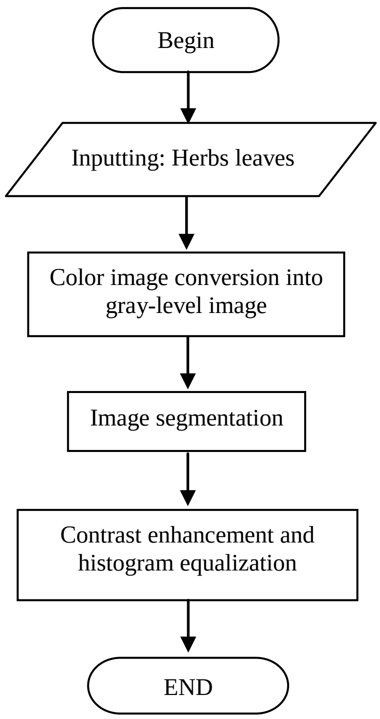

Fig. 1 Preprocessing flowchart

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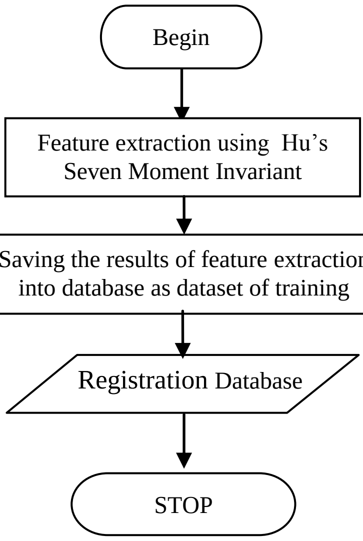

Fig. 2 Data training and registration flowchart

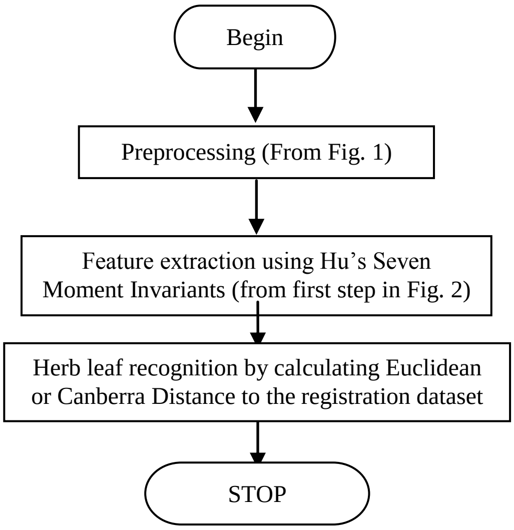

Fig. 3 Herb leaf recognition flowchart

B. Moment Invariant-based Feature Extraction

Two-dimensional $(p+q)^{th}$ order moment is defined:

$$m_{pq} = \sum_x \sum_y x^p y^q f(x,y), \quad p,q = 0,1,2,\ldots \tag{1}$$

If the image function $f(x,y)$ is a piecewise continuous bounded function, the moments of all orders exist and the moment sequence $\{m_{pq}\}$ is uniquely determined by $f(x,y)$; and correspondingly, $f(x,y)$ is also uniquely determined by the moment sequence $\{m_{pq}\}$.

One should note that the moments in (1) may be not invariant when $f(x,y)$ changes by translating, rotating, or scaling. The invariant features can be achieved using central moments, which are defined as:

$$\mu_{pq} = \sum_x \sum_y (x-\bar{x})^p (y-\bar{y})^q f(x,y), \quad p,q = 0,1,2,\ldots \tag{2}$$

where

$$\bar{x} = \frac{m_{10}}{m_{00}} \text{ and } \bar{y} = \frac{m_{01}}{m_{00}} \tag{3}$$

Then, the pixel point $(\bar{x}, \bar{y})$ can be said as the centroid of the image $f(x, y)$.

The centroid moments μ_{pq} computed using the centroid of the image $f(x, y)$ is equivalent to the m_{pq} whose center has been shifted to centroid of the image. Therefore, the central moments are invariant to image translations. Scale invariance can be obtained by normalization. The normalized central moments are defined as follows [2]:

$$\eta_{pq} = \frac{\bar{\mu}_{pq}}{\mu^{\gamma}{}_{00}}, \gamma = \frac{p+q+2}{2}, \quad p+q = 2,3,\ldots \tag{4}$$

Based on normalized central moments, Hu [3] introduced seven moment invariants:

$$\phi_1 = \eta_{20} + \eta_{02} \tag{5}$$

$$\phi_2 = (\eta_{20} - \eta_{02})^2 + 4\eta_{11}{}^2 \tag{6}$$

$$\phi_3 = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{03})^2 \tag{7}$$

$$\phi_4 = (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{03})^2 \tag{8}$$

$$\phi_5 = (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 3(\eta_{21} + \eta_{03})^2] + (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] \tag{9}$$

$$\phi_6 = (\eta_{20} - \eta_{02})[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03}) \tag{10}$$

$$\phi_7 = (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 3(\eta_{21} + \eta_{03})^2] + (3\eta_{21} - \eta_{03})^2(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] \tag{11}$$

where

Φ = moment invariant

η = normalized central moments

The seven moment invariants are useful properties of being unchanged under image translation, scaling, as well as under rotation.

C. Pattern Recognition using Distance-based Similarity

In this scheme, we used similarity measures for recognizing the herbal leaves. There are two similarity measures we have here, these are Euclidean Distance and Canberra Distance. The equations of both measures are given below.

The Euclidean Distance can be expressed as [6]:

$$D_{AB} = \sqrt{\sum_{k=1}^{n} (A_k - B_k)^2} \tag{12}$$

Where:
D_{AB} = Euclidean distance between feature *A* and feature *B*.
A_k = *k*-th tested feature vector
B_k = *k*-th reference feature vector
n = length of feature vector.

Whereas the Canberra distance can be determined by the equation below [7].

$$D_{A,B} = \sum_{k=1}^{n} \frac{|X_{Ak} - X_{Bk}|}{|X_{Ak}| + |X_{Bk}|} \quad (13)$$

Where:

$D_{A,B}$ = Canberra distance between feature *A* and feature *B*
N = number of feature vector
X_{Ak} = *k*-th tested feature vector (feature A)
X_{Bk} = *k*-th reference feature vector (feature B)

The image of the database that has the closest distance to the input image will be recognized as one of image from database in its recognition.

III. Results and Discussion

There are some tests conducted in the research.

A. *Recognition Test Results*

Tests conducted on 15 types of leaves, each leaf is composed of three types of trained images and 5 test images. Number of images were taken from one respondent is 9. Tests conducted to determine the success rate in identifying the types of leaves on the recognition system.

In testing of test images, as many as 75 images that were tested, 65 images are identified correctly. The recognition rate of this test is equal to 86.67%. The lowest percentage for the recognition is for *mangkokan* leaf type with a percentage of 40%. Graph of the test results using Euclidean Distance can be depicted in Figure 4. From this figure, it can be shown that there are 9 (nine) leaves types which results 100% recognition rate, i.e. banyan (*beringin*), *binahong*, *dolar*, *keji-beling*, laos, noni, papaya, red betel, and soursop leaves

While for the recognition using Canberra Distance, the recognition rate is only 72% which is resulted from the fact that only 54 correctly recognized images from the total of 75 tested images. The recognition percentage rate (P) is obtained by the calculation below.

$$P = \frac{54}{75} \times 100\% = 72\%$$

From 15 types of tested leaves, it can be found that *binahong*, *dolar*, *pecut kuda*, papaya, and red betel leaves have the highest recognition rate, i.e. 100%. While the lowest recognition rate, i.e. 20% for *keji beling* leaf. More detail for each type of leaf recognition can be illustrated in Fig. 5.

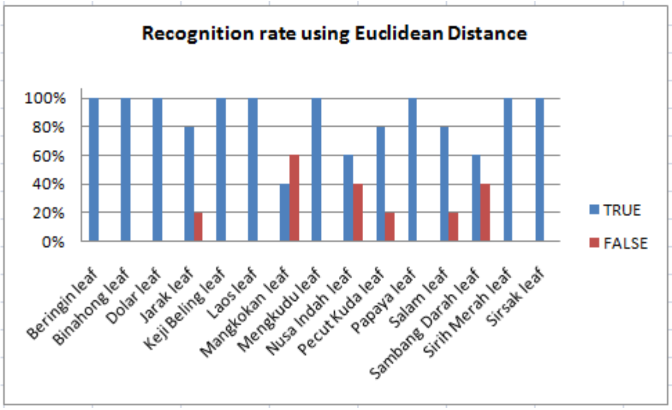

Fig. 4 Graphic of input image testing using Euclidean distance.

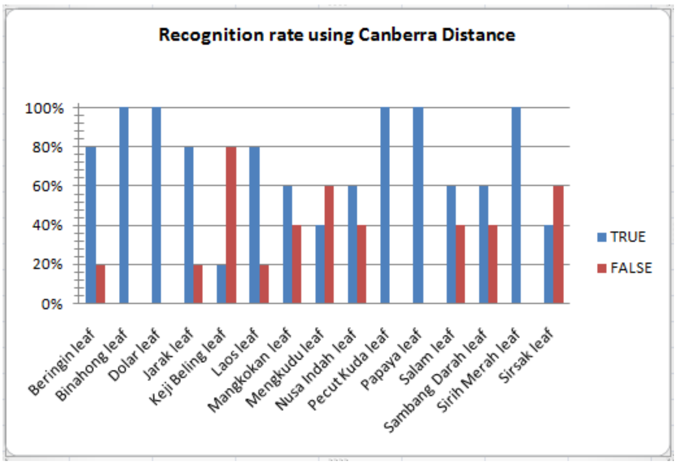

Fig. 5 Graphic of input image testing using Canberra distance.

There are three factors contributing the incorrect recognition on herbal leaf.

1. Similarity on leaves shape

In this recognition system, there are some leaves which have similar shape with other leaves, for which its feature extraction values also predictably similar. For example, bay (*salam*) leaf and noni (*mengkudu*) leaf both have elliptical shape, which is shown in Fig. 6.

(a) (b)

Fig. 6 (a) noni leaf; (b) bay leaf.

2. Scanning Results

In scanning process, it produces different image intensities, therefore it contributes to the variety on threshold values when converting the grayscale into binary images.

3. Different sizes from one type of leaf

The tested leaves from one type of herb leaf in this recognition process have different sizes. The different sizes from one type of leaf probably contribute on image segmentation results for which they can make the recognition process more difficult.

B. Testing on Seven Hu's Moment Invariants

Seven Hu's Moment Invariants is a feature extraction method which has 7 (seven) moment values which are invariant against geometrical operations on the image, i.e. the translation, change of scale, rotation and the reflection of the image (image mirroring). In this section we will discuss the testing of these positions.

Image being tested is an image that is used in the testing of test images, each image is made into a variety of positions. In this test there are seven kinds of positions that were tested, namely:

1. Initial position
2. Translation (shift)
3. Scaling (zooming/reducing size)
4. Rotation 90^0
5. Rotation 180^0
6. Vertical flip (mirrored against *y*-axis)
7. Horizontal flip (mirrored against *y*-axis)

After testing, it can be seen that feature extraction from 7 Hu's moment invariants is insensitive against its translation as well as for scaling positions. The values of 7 Hu's moment invariants in translation and scaling positions have different values at initial position. Therefore, it produces the different recognition. However, those differences are slightly small for that they are still in tolerable and permissible range of similar results.

In the position of both rotation and flip, all feature extraction of seven Hu's moment invariants almost produce similar values against its initial position and the recognition results in this position is similar with initial position's recognition result.

For the above reasons, it can be concluded that feature extraction using seven Hu's moment invariants has moment values which are invariants against its translation, scaling, rotation, as well as in mirror positions.

One example of test on seven moment invariant for *laos* leaf can be depicted in Table 1. This table shows recognition results on one example of *laos* leaf images as tested images with similarity measure used is Euclidean Distance.

In the next research, as future work, we will do research using more respondents or using large database of leaves which are available online. The limited amount of specimen of leaves is suspected of being the cause of the success rate is not satisfactory. The use of many samples leaves for training and testing are expected to produce the recognition rate that more trustworthy. There are some methods in preprocessing to produce images in order to get better images before extracted, e.g. image morphology [8], or do some research using spatial-transform such as Discrete Cosine Transform or wavelets [9], for which we can compare each method to get best recognition rate. We will also do some research in content-based retrieval which had been proposed by Marques and Furht [10] and using other method based on pattern recognition using machine learning which had been proposed by Bishop [11].

TABLE 1. RESULTS OF SEVEN MOMENT INVARIANT ON LAOS LEAVES

Position	Seven moment invariants values							Recognized as
	1	2	3	4	5	6	7	
Initial	0.81	17.79	14.89	17.25	33.64	18.43	34.08	Laos leaf
Translation	0.81	17.79	14.89	17.25	33.64	18.43	34.08	Laos leaf
Scale	0.82	17.79	14.89	17.25	33.64	18.43	34.08	Laos leaf
Rotation 90°	0.81	17.79	14.89	17.25	33.64	18.43	34.08	Laos leaf
Rotation 180°	0.81	17.79	14.89	17.25	33.64	18.43	34.08	Laos leaf
Vertical flip	0.81	17.79	14.89	17.25	33.64	18.43	34.08	Laos leaf
Horizontal Flip	0.81	17.79	14.89	17.25	33.64	18.43	34.08	Laos leaf

IV. CONCLUSIONS

From the testing has been done, it can be taken several conclusions as follows.

1. The recognition rate of herbal leaves using Euclidean distance similarity measure is 86.67%. While, the lowest recognition rate is 40% for *mangkokan* type of leaf. Some leaves shapes which are alike affect to the leaf-type recognition. This is because the recognition of two type of leaves produce similar seven Hu's moment invariants which are able to make some identification errors. For example: some noni leaves are recognized as bay leaves.
2. The recognition rate of herbal leaves using Canberra distance similarity measure is 72%. While, the lowest recognition rate using this similarity measure is 20% for *keji-beling* type of leaf. For this case, Euclidean distance is better that Canberra distance in recognizing the herb leaves types when we use Seven Hu's Moment Invariants in feature extraction.
3. The values of seven Hu's moment invariants are sensitive against scale changes. It can be seen that some different recognition results when scaling were modified. Dapat dilihat ada beberapa hasil pengenalan yang berbeda pada posisi skala. The larger the scaling factor, the recognition rate will decline.

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