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Automatic Detection of Corn Leaf Desease by Using Fuzzy C-Means Algorithm and Morphological Operation

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ABSTRACT : *Corn is the second staple food after rice in Indonesia, therefore corn cultivation is an important issue in agriculture in Indonesia. Problems often occur in corn cultivation, one of which is corn leaf spot disease. Monitoring the health of corn plants is an important problem to increase the corn production. Health monitoring of corn plants in large areas requires a corn disease detection system that automatically detects symptoms that appear on the leaves of corn using imaging technology. This system will help in growing healthy plants on the farm. However, it is not an easy task to detect corn leaf spot disease automatically. A method is needed that can facilitate the detection of corn leaf spots. One method that can be used to detect corn leaf is the image segmentation method. The Fuzzy C-Means algorithm has proven that it can handle large, unclear and uncertain data collections. This paper will propose automatic detection of corn leaf disease using the Fuzzy C-Means algorithm. Since the results of image segmentation by the Fuzzy C-Means algorithm are not yet appropriate, the morphological operations are used to improve the results. From the test results, it is obtained the accuracy values above 99%. It shows that the method proposed by the authors is very good to be applied in the process of segmenting the image of corn leaf spots.*

KEYWORDS *corn leaf spots,Fuzzy C-Means,Morphological operation*

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I. INTRODUCTION

Corn is the second staple food after rice in Indonesia. One of the problems faced by farmers in corn cultivation is a biotic disorder both disruption by macro organisms (pest disorders) or interference by microorganisms (disease disorders). Disorders by microorganisms can be classified into three categories: fungi, bacteria and viruses. One of the corn leaf diseases caused by fungi and has a significant impact on corn production is leaf spots. Since past few years, leaf spots disease became the major problem to reduce grain yield in these regions. It was estimated that a 50-100% yield loss was observed in Bhutan and >80% was estimated in Nepal [1]. In Indonesia, some reports regarding the reduced yield of corn due to leaf spot, which ranges from 5-50%. If leaf spots attack corn plants before female flowers appear, then the yield reduction can reach 50% [2]. Thus, monitoring the health of corn plants is an important problem to increase corn production.

Monitoring the health of corn plants in large areas requires a system of automatic detection of corn leaf spots using image processing technology. There have been many previous writings regarding image processing for classification, segmentation, sorting, and detection of diseases in plants with fairly accurate and fast. This time, the author tried to use the segmentation method in image processing to overcome the problem of monitoring the health of corn plants, especially detecting corn leaf spots. However, sometimes it is difficult to distinguish between normal corn leaves and corn leaves which are attacked by leaf spot disease, and it is not an easy task to detect corn leaf spot disease automatically.

The Fuzzy C-Means algorithm is a data clustering technique in which the existence of each data point in a cluster is determined by the degree of membership. This technique was first introduced by JmBezdek in 1981 [3]. The advantages of Fuzzy C-Means are being able to cluster more than one variable at a time. Two of the previous writings related to Fuzzy C-Means in image segmentation namely “Analysis of Liver Ultrasound Segmentation Using Fuzzy C-Means Method” [4] and “Implementation of Fuzzy C-Means Algorithm and Statistical Region Merging in Image Segmentation” [5]. From the previous writings, it has been proven that with the advantages possessed, the Fuzzy C-Means algorithm is quite good at handling image segmentation with different problems in it. However, the Fuzzy C-Means algorithm also has a weakness in the image segmentation process, which is sensitive to noise [6]. In the case of the detection of corn leaf spots, noise is not so important because in this process the most important thing is the detection of color components. For this reason, this paper will propose the automatic detection of corn leaf disease using the Fuzzy C-Means algorithm. To support the results of image segmentation using the Fuzzy C-Means algorithm but not yet in accordance with the direction of experts, the authors carried out morphology in this case using closing operations and filling holes operations. Morphology has proven to overcome many problems related to the shape and structure of an object. Morphology is used to process the structure of an object in an image in such a way that the desired object structure is obtained.

II. PROPOSED METHOD

In this article, images of corn leaf spots obtained from farmers' land in Blimbing District, Malang Regency, assisted by Malang Agricultural Technology Assessment Agency (BPTP) officers in identifying diseases in the leaves of corn which will be used as research sample data. The introduction of this leaf spot image will be used to draw the image of corn leaf spots manually. This is very instrumental in determining the value of accuracy. For more details about the proposed method, you can see the flowchart in **Figure 1** below:

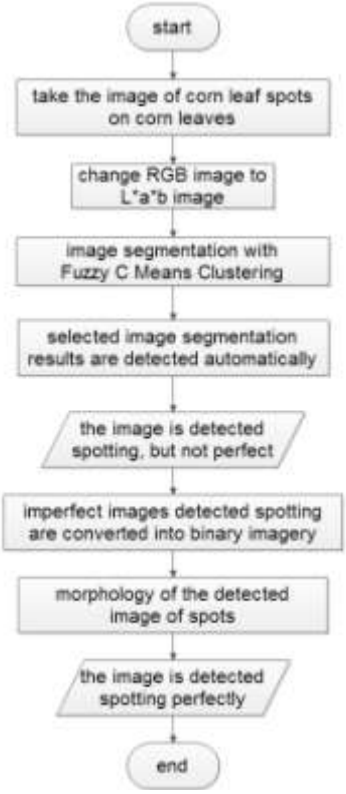

Figure 1.Flowchart of the proposed method

2.1. Corn Leaves.

Corn leaf spots are one of the corn leaf diseases caused by fungi or fungi. Based on the results of identification of symptoms of attack of leaf spot disease and observations using a microscope on the shape of conidia, it is known that leaf spot disease in corn plants is caused by fungi Curvulariasp. The initial symptom caused by this disease is the appearance of irregular brownish small spots measuring 1-2 mm, the initial symptoms occur in the first leaf, then develop into the upper leaves. These small spots will later fuse and will experience necrosis, eventually the leaves will dry up and die. If the attack rate is higher, this disease can attack the stem organ or corn cobs [1].

An example of corn leaf spot image can be seen in **Figure 2**:

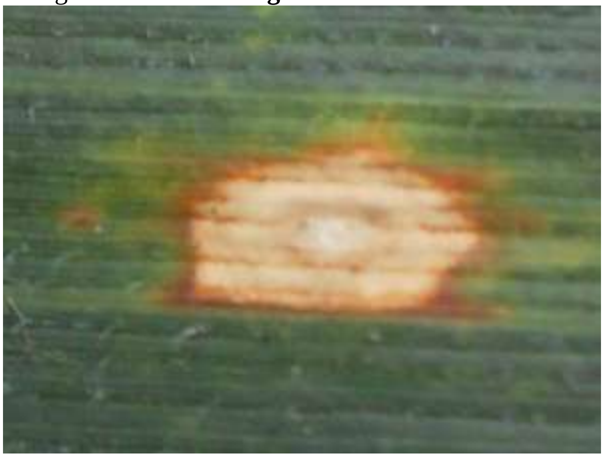

Figure 2.Corn leaf spots

In the trial, the authors used three images of corn leaf spots.

2.2. RGB Color Space to $L^*a^*b^*$ Color Space.

The original image of the corn leaf spots in this article is an RGB image. Red, Green, Blue (RGB) color space is a primary color combination of red, green and blue which is usually used for computers or televisions. The colors used each have a value of 8 bits in red, 8 bits in green, and 8 bits in blue [7]. In this experiment, the RGB image must be changed first into the $L^*a^*b^*$ image because this experiment is very dependent on the detection of color components. The $L^*a^*b^*$ Color Space also known as CIELAB is the most complete color space set by the International Commission on Color Illumination (French Commission International de l'eclairage, and also known as CIE). The color space $L^*a^*b^*$ can describe all the colors that can be seen by the human eye and are often used as references to color space. The color space can be done through the XYZ color space through the following equation:

$$L^* = 116\left(\frac{Y}{Y_0}\right)^{1/3} - 16 \text{ for } \frac{Y}{Y_0} > 0.008856 \quad (1)$$

$$L^* = 903.3\left(\frac{Y}{Y_0}\right)^{1/3} - 16 \text{ for } 0.0 \leq \frac{Y}{Y_0} \leq 0.008856 \quad (2)$$

$$a^* = 500\left[f\left\{\frac{X}{X_0}\right\} - f\left\{\frac{Y}{Y_0}\right\}\right] \quad (3)$$

$$b^* = 200\left[f\left\{\frac{Y}{Y_0}\right\} - f\left\{\frac{Z}{Z_0}\right\}\right] \quad (4)$$

where,

$$f(w) = w^{1/3} \text{ for } w > 0.008856 \quad (5)$$

$$f(w) = 7.787(w) + 0.1379 \text{for} 0.0 \leq w \leq 0.008856 \quad (6)$$

The XYZ color space, also known as the CIE XYZ color space, is obtained from the RGB color space transformation through a 3 × 3 matrix transformation process. Transformation involves tristimulus values, namely a configuration of three linear light color components that meet CIE color matching.

Calculation for transformation from RGB color space to XYZ, can be done through calculation of transformation matrix with the following equation:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0,412453 & 0,357580 & 0,180423 \\ 0,212671 & 0,715160 & 0,072169 \\ 0,019334 & 0,119193 & 0,950227 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (7)$$

Color space $L^*a^*b^*$ stands for Luminance where a^* and b^* are colored components. According to the $L^*a^*b^*$ model, a^* is represented as a component between green to red and b^* as a component between blue to yellow. The $L^*a^*b^*$ model is designed to be an independent model or can handle colors regardless of certain devices such as printers, monitors, or computers. Luminance ranges from 0 to 100, components a^* range from -128 to +127 (green to red), and components b^* range from -128 to +127 (blue to yellow). $L^*a^*b^*$ aims to equate perceptions and components of L^* which are very suitable for human perception. This is used to correct accurate color balance by modifying the output curve in components a^* and b^*, or to adjust the contrast lightly using the component L^*[8].

2.3. Image Segmentation with Fuzzy C-Means Clustering.

Image is a picture, resemblance, or imitation of an object. Image segmentation aims to divide homogeneous regions. Segmentation must be stopped if each object has been isolated or clearly visible [9]. In this paper, the image segmentation process is done using clustering techniques, which are processes that group data in classes or clusters so that the data in a cluster has a high level of similarity between the data with each other but very different from the data in other clusters [10].

Fuzzy C-Means is an example of a data clustering algorithm that has a basic concept of initially determining the center of a cluster that will mark the average location for each cluster. In the initial condition the cluster center was still not accurate. Each data point has membership degrees for each cluster. By improving the cluster center and the degree of membership of each data point repeatedly, the cluster center will move to the right location. This repetition is based on the minimization of objective functions that describe the distance from the data point given to the cluster center which is weighted by the degree of membership of the data point. The output of Fuzzy C-Means is a cluster center series and several degrees of membership for each data point [11]. The Fuzzy C-Means method is the most popular method and many found new fuzzy clustering algorithms derived from the algorithm. However, Fuzzy C-Means has the disadvantage of being sensitive to noise making it less effective in cases that consider noise very much [6].

The following is an algorithm from Fuzzy C-Means that has been adapted to this experiment [12]. The following sample data is written on one of the corn leaf spots.

a. Applying the initial U matrix is a matrix size of $n \times m$ ($n =$ number of sample data, which is 17.328 and $m =$ attribute of each data, which is 3), X_{ij} = data-i ($i = 1,2,\dots,n$), attribute-j ($j = 1,2,3$).

b. Determine:

Number of clusters $= 3$
Weighting exponent $= 2$
Maximum iteration $= 100$
Smallest error expected $= 10^{-5}$
The initial objective function $= P_0 = 0$
Initial iteration $= t = 1$

c. Generating random numbers μ_{ik}, $i = 1,2,\dots,n$ and $k = 1,2,3$ as elements of the U initial partition matrix. Then calculate the number of each column (attribute):

$$Q_j = \sum_{k=1}^{c} \mu_{ik} \text{ with } j = 1,2,3 \quad (8)$$

d. Calculates the center of the cluster-k: V_{kj} with $k = 1,2,3$ and $j = 1,2,3$

$$V_{kj} = \frac{\sum_{i=1}^{n}((\mu_{ik})^w * X_{ij})}{\sum_{i=1}^{n}(\mu_{ik})^w} \quad (9)$$

e. Calculate the objective function in the teration-t

$$P_t = \sum_{i=1}^{n}\sum_{k=1}^{c}\left(\left[\sum_{j=1}^{m}\left(X_{ij} - V_{kj}\right)^2\right](\mu_{ik})^w\right) \quad (10)$$

f. Calculate changes to the partition matrix

$$\mu_{ik} = \frac{\left[\sum_{j=1}^{m}(X_{ij} - V_{kj})^2\right]^{\frac{-1}{w-1}}}{\sum_{k=1}^{c}\left[\sum_{j=1}^{m}(X_{ij} - V_{kj})^2\right]^{\frac{-1}{w-1}}} \quad (11)$$

g. Check the stop condition

A. If ($|P_t - P_{t-1}| < 10^{-5}$) or $t > 100$, then stop

B. If it doesn't meet point (A), then $t = t + 1$, repeating step d

When the Fuzzy C-Means program is run automatically on the image of corn leaf spots, there is a result image that is not suitable. The image of a white leaf spot (leaf spots are aging) is compared with the image of a normal corn leaf, so morphological help is needed to cover the white spots so that they are still classified as spots. To do the morphological process, the $L^*a^*b^*$ image must be converted into a binary image. Binary imagery consists of only two colors, namely black and white [9].

2.4. Morphology.

Morphology is used to extract image components that are useful in representation and description of a region in the image. The morphology used in this paper is a combination of Closing and Filling Holes. In the closing operation, a dilation operation is carried out first, then followed by erosion operations, A • B = (A ⊕ B) Θ B. The dilation operation is usually used to obtain a widening effect on pixels which is worth 1, which is formulated $A \oplus B = \left\{z \mid \left[(\hat{B})_z \cap A\right] \subseteq A\right\}$. Set B is called "structuring element" in dilation. This equation is based on reflecting B on its origin, and reflection shifts by z. Whereas erosion has the effect of reducing the surface area of an area or object which has white intersection. This operation is formulated $A \ominus B = \left\{z \mid (B)_z \subseteq A\right\}$.

Filling holes aim to fill the entire region with a value of 1 in the boundary, if the non-boundary point is labeled 0. This operation uses a reference based on the value of neighboring pixels. Starting from point p in the boundary, the following procedure will fill the region with a value of 1.

$$X_k = (X_{k-1} \oplus B) \cap A^c \qquad k=1,2,3,\ldots \qquad (12)$$

with $X_0 = p =$ the initial hole of image A, $B =$ structuring element, and $A =$ image with a hollow object. The algorithm stops at iterations to k, if $X_k = X_k - 1$. The combination of X_k and A is the set of contents of the region and boundary [13]. After the morphological process is carried out, the results of image segmentation obtained from the proposed method will be compared with the image of manual corn leaf spots from expert direction. Next, the two leaf spot images of corn will be checked for accuracy.

III. RESULT AND DISCUSSION

In this test, the authors used three images of corn leaf spots of the same size, measuring 152×114 pixels. The device used is a computer with specifications: Intel Pentium dual core 1.87 GHZ Memory 3GB, Windows 7 32 Bit Operating System. The programming language used is MATLAB R2013a. First, the author converts an RGB image on corn leaf spots into an image of $L^*a^*b^*$, and segmentes the corn leaf spots image. In looking for the value of accuracy, the author uses the application GIMP 2.10.8 to describe the image of corn leaf spots according to the direction of the expert and the results will be used to determine accuracy along with the image of corn leaf spots automatically from the proposed method.

3.1. Test Result

For the first corn leaf spot image, the results of detection of leaf spot images can be seen in **Figure 3b, Figure 3c, 3d Figure, Figure 3e** and **Figure 3f** below:

Figure 3a. Image of original corn leaf spots.

Figure 3b. Segmented image with Fuzzy C-Means that has been refined.

Figure 3c. Image segmentation results with Fuzzy C-Means and Filing Holes.

Figure 3d. Image segmentation results with Fuzzy C-Means, Filing Holes, and Closing.

Figure 3e. Image of manual spots according to expert direction.

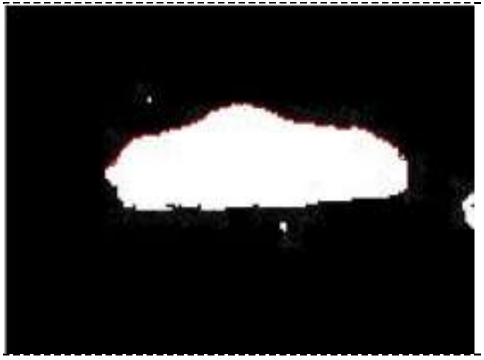

Figure 3f. Image of segmentation results with the proposed method and manual spot image.

For the second corn leaf spot image, the results of detection of leaf spot images can be seen in **Figure 4b, Figure 4c, Figure 4d, Figure 4e** and **Figure 4f** below:

Figure 4a. Image of original corn leaf spots 2.

Figure 4b. Segmented image with Fuzzy C-Means that has been refined.

Figure 4c. Image segmentation results with Fuzzy C-Means and Filing Holes.

Figure 4d. Image segmentation results with Fuzzy C-Means, Filing Holes, and Closing.

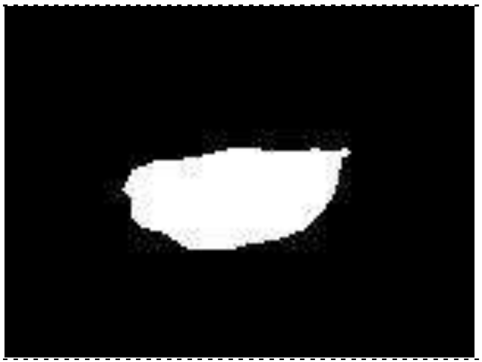

Figure 4e. Image of manual spots according to expert direction.

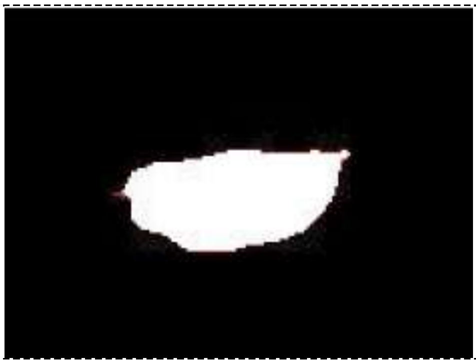

Figure 4f. Image of segmentation results with the proposed method and manual spot image.

For the image of the third corn leaf spot, the results of detection of leaf spot images can be seen in **Figure 5b, Figure 5c, Figure 5d, Figure 5e** and **Figure 5f** below:

Figure 5a. Image of original corn leaf spots 3.

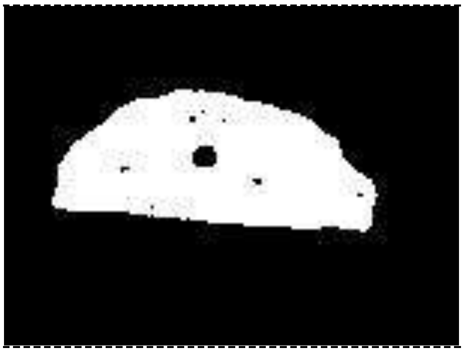

Figure 5b. Segmented image with Fuzzy C-Means that has been refined.

Figure 5c. Image segmentation results with Fuzzy C-Means and Filing Holes.

Figure 5d. Image segmentation results with Fuzzy C-Means, Filing Holes, and Closing.

Figure 5e. Image of manual spots according to expert direction.

Figure 5f. Image of segmentation results with the proposed method and manual spot image.

In **Figure 3b, Figure 4b**, and **Figure 5b**, the results of image segmentation are not perfect. There are some images of leaf spots that are not detected as spots. The segmented images in **Figure 3c** and **3d**, **Figure 4c** and **4d**, and **Figure 5c** and **5d** look very similar, but if you look more closely, **Figure 3d** have perfected the detection of leaf spots in **Figure 3c** on the edge of the spot. Likewise, **Figure 4d** enhances **Figure 4c**, and **Figure 5d** enhances **Figure 5c**. **Figure 3d**, **4d**, and **5d** are the final results of the image segmentation proposed by the author. In **Figure 3f, Figure 4f,** and **Figure 5f,** the edges of white spots are the images of manually drawn spots, while the edges of the red spots are the images of spots using the proposed method. From the picture, it can be seen that the two edges of the spot are very tight, although not 100%. This proves that the proposed method is very good and very close to the image of the spot directed by experts.

3.2. Accuracy.

Calculation of accuracy value based on following formula [14]:

$$accuracy = \frac{TP+TN}{TP+TN+FP+FN} \quad (13)$$

Information:

TP =the image of corn leaf spots from the program and the image of corn leaf spots from experts are equally appropriate

TN =the image of corn leaf spots from the corresponding program while the image of corn leaf spots from experts is not appropriate

FP =the image of corn leaf spots from the program not and the image of corn leaf spots from experts is equally inappropriate

FN =the image of corn leaf spots from the program is not suitable while the image of corn leaf spots from experts is appropriate

The value of accuracy obtained from the results of trials on this paper is presented in Table 1:

Table 1. Value of accuracy of each image

No	Image	Accuracy × 100%
1	Image of the spot 1	99,48%
2	Image of the spot 2	99,71%
3	Image of the spot 3	99,23%

The value of accuracy obtained from testing all three images is above 99%. This shows that the program created by the author is as expected, namely the image of corn leaf spots from program segmentation is almost entirely in accordance with the image of corn leaf spots directed by experts. Note that need to be considered is the accuracy of the accuracy value is also very dependent on our accuracy in drawing the image of corn leaf spots manually. The more thorough in manual drawing according to expert directives, the higher the accuracy of the accuracy value.

IV. CONCLUSION

Based on the test results and the accuracy value obtained, it can be seen that the method proposed by the writer is very good to be applied in the problem of image segmentation between corn leaf spots and normal or healthy corn leaves automatically. Thus, it is expected that the method proposed by this writer can be utilized to the maximum extent possible for the process of planting healthy plants among Indonesian farmers, especially corn farmers.

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