Simple Screening Method of Maize Disease using Machine Learning

Chyntia Jaby ak Entuni, Tengku Mohd Afendi Zulcaffle

Abstract*: *Plant leaf diseases are significant issue in agriculture field. Some of the common plant leaf diseases are powdery mildew, dark spot and rust. They are a noteworthy wellspring of an immense number of dollar worth of setbacks to farmers on a yearly premise. Plant breeders frequently need to screen countless number of plant leaves to find the stage of diseases of their crops to perform an early treatments. Therefore, a robust method for field screening is needed in order to spare the farmers and the environment as well. Inappropriate used of treatments such as impulsive pesticides can imperil the environment. Hence, this paper present a simple and efficient machine learning method which is Fuzzy C-Means algorithm to screen leaf disease severity in maize. Fuzzy C-Means is a new algorithm and very efficient to be used in object detection. Therefore, it is applicable to detect disease spot in plant leaf and measure the diseases severity. This field screening method help the farmer to identify the progression of the diseases in their crops quicker and easier than the other field screening techniques.

Keywords*: *Plant leaf disease, Field screening, Machine learning, Fuzzy C-Means, Maize.

I. INTRODUCTION

Maize is the second important crop in Asia after rice [1]. Maize is a yield of various uses and is a nutritious nourishment for human consumption. Therefore, it is something that requires more noteworthy advancement to improve sustenance crosswise over countries in Asia like Malaysia, India, Indonesia, Bangladesh and Nepal. Rice-Maize systems currently occupy approximately 3.5 million hectares in Asia and the highest acreage is in India [2]. However, maize is frail to various leaf diseases and slow treatments will lead to major yield losses. The most commonly used method worldwide to screen leaf disease progression is visually or naked eyes observation which is inadequate [3]. Naked eyes observation was also time consuming and expensive especially in rural areas and developing countries [4]. Consequently, efficient field screening method to recognize the infections from the indications that show up on the maize leaf is of extraordinary sensible importance.

This paper demonstrates a time-efficient field screening method of leaf disease in maize using machine learning. Fuzzy C-Means algorithm was utilize in the experimentation to segment and categorize an infected part of the leaf from the uninfected part. Fuzzy C-Means is a powerful unsupervised clustering algorithm which has been widely used for categorization problems [5]. For example, it has been used in medical field to distinguish abnormal and healthy lungs [6] and to detect tumor region in brain [7]. Fuzzy C-Means also used in the marine application so as to identify oil spills area in the ocean which has dangerous effects to the eco system [8]. Other than that, it can be applied in vehicle classification for traffic surveillance and management [9] and to predict the high possibility of crime incidence by visualizing the crime analysis in various states in US by using USArrests dataset [10].

Fuzzy clustering is a powerful method to solve problems in the areas of pattern recognition. Therefore, it is very suitable to be used in this studies to screen diseases in maize leaf which is based on the pattern disorders of the leaf. Fuzzy C-Means is an optimal algorithm for segmentation. Objects segmented using Fuzzy C-Means are not completely belong to one of the classes but assigned in the range of 0 and 1 [11]. Hence, it more natural than other segmentation algorithm and applicable to be used in this study.

II. METHODOLOGY

The Fuzzy C-Means algorithm first introduced by J. C. Bezdek [12]. Idea of FCM is using the weights that minimize the total weighted mean-square error:

$$J(wqk, z(k)) = \sum(k=1,K)\sum(k=1,K)(wqk)\|x(q)-z(k)\|^2 \quad (1)$$

$$\Sigma\,(k=1,K)\,(wqk) = 1 \text{ for each q}$$

$$wqk = (1/(Dqk))2)1/(p-1)/\sum(k=1,K)(1/Dqk)2)1/(p-1), p\rangle 1 \quad (2)$$

Fuzzy C-Means allows each feature vector to belong to every cluster with a fuzzy truth value (between 0 and 1), which is computed using Equation (4). The algorithm assigns a feature vector to a cluster according to the maximum weight of the feature vector over all clusters. In this study, the maximum weight is infected area and it will be segmented from uninfected area.

Dataset used in this study is the images of maize from PlantVillage Image dataset. There are 30 images of maize used for experimentation purposes. The images were comprises of various maize leaf diseases. The infected area of the leaf were segmented using Fuzzy C-Means method by using MATLAB R2018b software. Percentage of Infection (POI) for segmentation were recorded. Figure 1 shows the process block diagram of the screening of leaf disease in maize.

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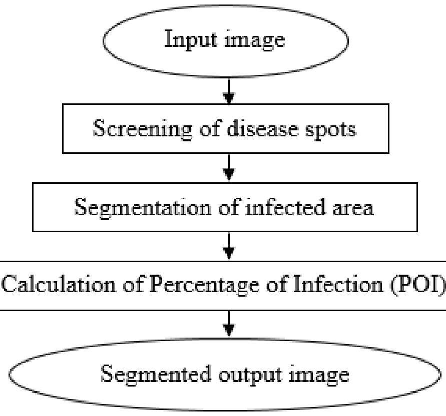
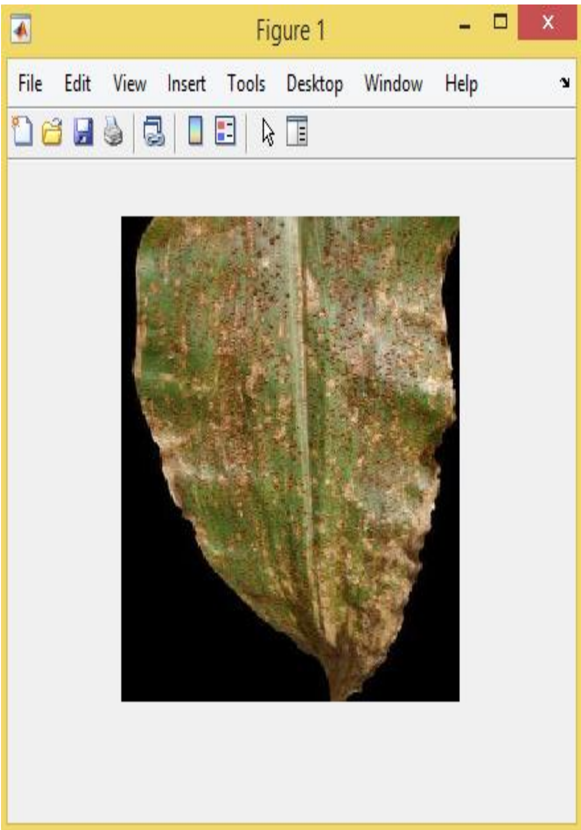


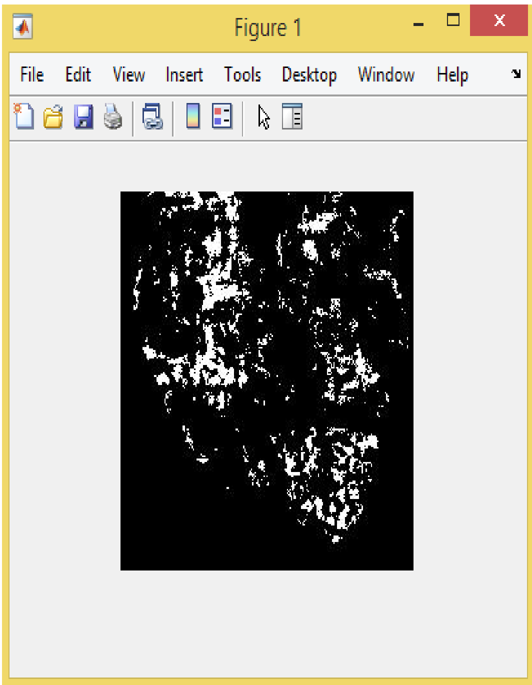
Fig. 1: Process block diagram of maize leaf screening.

III. RESULT AND DISCUSSIONS

During the screening of diseases spot, Fuzzy C-Means algorithm was programmed to automatically detect the green region of the leaf and segment it from grey region which is diseases region. After being segmented, the only region left in the leaf image was infected area. Figure 2 shows an example of maize leaf image before and after being segmented using Fuzzy C-Means. The images were converted from RGB to binary image to enable the algorithm to calculate the infected area of the leaf based on total number of pixels. Binary image is simply reducing complexity of the image which is from a 3D pixel value (R,G,B) to a 1D value [13]. 3D pixels is much more complex than 1D pixels. Therefore, many tasks do not fare better with 3D pixels [13].



(a) Before segmentation.



(b) After segmentation.

Fig. 2: Maize leaf before and after being segmented using Fuzzy C-Means.

To convert RGB to binary image, firstly get the values of three primary colours which are Red, Green and Blue [14]. After that, encodes this linear intensity values using the gamma expansion. The gamma expansion is:

$$C_{linear} = \begin{cases} \dfrac{C_{rgb}}{12.92}, C_{rgb} \leq 0.04045 \\ \dfrac{(C_{rgb} + 0.065)}{1.065}, C_{rgb} \rangle 0.04045 \end{cases} \quad (3)$$

From expansion (3), C rgb is RGB primaries in the range from 0 to 1. While C linear is the linear-intensity value which also has the range from 0 to 1. Then the luminance of the output image is accomplished using weighted sum of the three linear intensity values. The conversion is achieved using the function:

$$y = f(x) \quad (4)$$

Lastly, x is the original input data and y is the converted output data. Using weighted sum of the R, G, and B components, the function f(x) converts RGB values to grayscale values by:

$$f(x) = 0.2989 * R + 0.5870 * G + 0.1140 * B \quad (5)$$

After segmentation was done, Percentage of Infection (POI) of maize was calculated and recorded as in Table 1. POI was obtained from the comparison of disease spot segmented leaf image with image that was only segmented in the background of it. Area of infected leaf identified automatically during Fuzzy C-Means segmentation. Efficiency in general describes the extent to which resources such as time, space, energy [15]. Hence, computational time taken by this machine learning field screening method was also identified. Time taken to screen 30 images of maize leaf was 19.28s which makes this field screening method really efficient to use by the farmers.

In addition, it is proven in Table 1 that the proposed Fuzzy C-Means algorithm is very easy to examine and used by the farmers with simple indication which is by percentage of infection achieved.

Table 1: Percentage of infection of maize leaf.

Infected Maize Leaf	Percentage of Infection (%)
1.	77.88
2.	67.90
3.	66.77
4.	75.96
5.	98.04
6.	87.64
7.	8.95
8.	31.15
9.	64.85
10.	69.65
11.	92.85
12.	90.62
13.	80.59
14.	78.29
15.	35.42
16.	43.08
17.	80.69
18.	49.63
19.	63.39
20.	77.97
21.	91.97
22.	85.71
23.	75.20
24.	79.98
25.	28.83
26.	78.51
27.	77.70
28.	81.29
29.	61.30
30.	54.76

From the result of POI obtained, farmers can identified and estimate the severity of diseases in their crops. This will facilitate the work of farmers in treating damaged parts of their crop fields. Improper care will influenced the quality, quantity and lastly productivity [16]. Hence, precise recognition of plant infection is expected to fortify the field of agribusiness and economy of specific nation [17]. By using the proposed field screening method in this study, farmers can easily planned their treatments.

For example, they can screen and monitor their crop fields by part based on small sample of leaf dataset from their crops. Figure 3 shows the graph of diseases severity of 30 maize leaf images. This graph can conclude the severity of the diseases in that small part of the specific region. It is much simpler and more accurate than when farmers need to screen their plants in large quantity in one time. Garcia et al. [18] also stated in their studies that crops may extend for extremely large areas, making monitoring a challenging task. Therefore, field screening using machine learning method is very practical to be used.

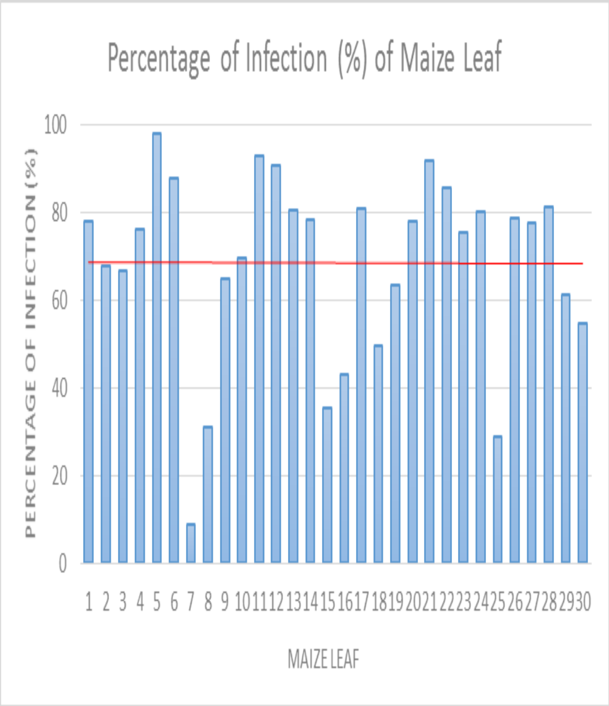


Fig. 3: Disease severity of 30 maize leaves.

From this graph, the average percentage of infection in the red underline experienced by this group of maize leaf was 68.54%. Hence, the farmers will have a knowledge of which one of their group of plants need to undergo removal of leaf before the diseases spreading to other parts of the plants. In that way, the farmers can consider to adjust the spacing of their plants from each other. The efficacies of two cultural control measures were assessed which are altering the spacing of host plants, and rogueing symptomatic parts and it was proved to be cost-effective [19].

IV. CONCLUSION

In this paper, simple and efficient field screening method of leaf disease in maize using machine learning is presented. This method is proven to be easier to use by the farmers although they are not very familiar at using technology because it is very easy to practice. It is only by screening the infected maize leaf using the proposed Fuzzy C-Means algorithm in this study and getting the result of percentage of infection in the leaf really fast (19.28s for 30 maize leaves). It is safe to say that simpler, time-efficient, energy-efficient and user-friendly is the right words to describe the proposed field screening method in this study. Traditional method of using naked eyes observation which is time consuming and complicated also can be left behind. However, it can still be improved by extension used in mobile application. As [20] stated that the usage of mobile application changing the way human live in terms of increasing in reliability.

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