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An Edge Detection Algorithm to Identify Multi-Size Lesions

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Abstract— Lesions in images can be detected using several edge detection methods such as Canny, Sobel, Roberts and Prewitt. However, all of these methods are time consuming in detecting lesions. The reason being each of the pixels is serially searched from top to bottom and from left to right in the image. In addition, a lesion can only be detected when all pixels have been completely searched. The methods are inefficient as some of pixels, usually at the edge of a lesion fail to be detected. This paper presents experimental results on an algorithm that was developed based on Artificial Bee Colony (ABC). Results showed that ABC produced a better percentage of correctness and the detection time than others edge detection methods such as Canny, Sobel, Roberts and Prewitt. The study has the potential to make a substarartial contribution to the body of knowledge in the image processing agriculture intelligence areas.

Index Terms—Object detection; Leaf, Lesion; Grayscale pixels; Artificial Bee Colony

1 BACKGROUND

Lesions are patches of dead cells that may be found on leaf surfaces and their existence strongly indicate that the plant has a disease [1-2]. A plant will die if there are too many lesions. This is because lesions cause a reduction in green surface of plant leaves, causing a reduction in chlorophyll. Since chlorophyll is responsible for providing food to plants through photosynthesis, its insufficiency may cause plants to die. This phenomenon shows that lesions and plant disease are correlated. Therefore, investigating the size of the affected leaf surfaces (lesions) can indicate the severity of a plant disease. In general, the term "severity" refers to the percentage of seriousness of a plant disease [1]. It has been a common practice to categorize plant disease severity into five categories: grade 0 (apparently infection-free), grade 1 (0 – 25% leaf area infected), grade 2 (26 – 50% leaf area infected), grade 3 (51 – 75% leaf area infected), and grade 4 (>75% leaf area infected) [2].

A variety of methods have been used to determine the level of severity and color features is one of the methods [3]. In particular, the Leaf Color Chart (LCC) has been popularly and manually used by farmers to classify the plant disease severity level. However, there are certain problems with the use of LCC. One problem is that LCC results to a rather low percentage of classification accuracy. This is due to the fact that the method perform classification based on the color of the whole leaf. Another problem is LCC takes a longer time to determine the level of severity - it is time-consuming process. To address the problems, computerized methods have been used. These include the use of image segmentation methods such as edge detection, thresholding and region methods to determine and analysis plant disease [4],[5],[6]. The methods though give slightly better results in terms of time and accuracy, their methods require higher memory capacity.

Others studies have tried to incorporate intelligent techniques in their detection methods. Examples are using fuzzy logic [7], K-Means [5], clustering [8], and artificial neural networks [9]. These methods still could not give a significant performance improvement in terms of time and classification accurateness [10]. The reasons were the methods were focusing on the colour of the whole leaf to determine the disease level, resulting inaccurateness in classification. To solve the problem, Canny, Sobel and Otsu were used in [11],[12],[13],[14][15] tried using lesions as a means to determine the level of disease severity instead of the whole leaf. In order to detect a lesion, Canny, Sobel and Otsu will search each pixel on the the leaf surface. This process consumes time. However, the method could not detect correct edge pixels if the colour of lesion and leaf is almost the same or the leaf image is blurr.

Recent evidence suggests that Artificial Bee Colony (ABC) is able to handle problems related to thresholding, segmentation and object detection. For example, [16] proposed an automated threshold selection algorithm based on ABC and compared its performance with Otsu algorithm. The results showed that the performance of ABC algorithm was better than Otsu algorithm. In another research, [17] proposes a global multi-level thresholding method for image segmentation based on ABC. They used ABC to improve time and identified that ABC was faster than GA and PSO. Fast segmentation in Synthetic Aperture Radar (SAR) using ABC was proposed by [18]. The objective of their study was to enhance threshold optimal value of grayscale color between pixels.

They found that ABC produced better accuracy in segmen-

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tation and time than Artificial Fish Swarm (AFS) and Genetic Algorithm (GA). Application of ABC for recognition of an object within certain images was introduced by [19]. The objective of their work was to find a pattern or template of an object anywhere on a target scene. The experimental results, using grayscale and color images showed that the performance of ABC was faster in finding a pattern than a comparable technique such as Evolutionary Algorithm (EA). However, in terms of object detection using ABC, reviews of past literatures showed that no work has been done on lesion detection. The positive reviews produced from past works have resulted in an attempt to use ABC in detecting an object, specific lesions [20].

This study focuses on detecting multiple lesions in images. An algorithm based on ABC was developed to detect lesions in grayscale images. The algorithm was measured in terms of percentage of correctness, percentage of error and detection time.

2 APPROACH

The research was conducted in three phases, data preparation, algorithm and analysis.

PHASE 1: Data preparation

In this phase, the data used are taken from www.forestryimages.org. The data consists of four images that less contains than fifteen lesion. Three steps involved in this phase: convert images from JPEG or RGB to TIFF; convert TIFF images into grayscale; and perform data cleansing. The steps for the phase are described below.

Step 1: Convert images from JPEG or RGB to TIFF

It consisted of four green color images that are in RGB and JPEG format. The images were converted to TIFF format using Microsoft Paint software. The original image is stored in JPEG, a significant change occurred during conversion from an original image to JPEG and this causes some image distortion. However, when an image is stored in TIFF, the change is very minimal. This results in a less distorted image. Therefore, images in TIFF are sharper than images in JPEG. Fig. 1(a) and 1(b) show two images before conversion and after conversion respectively.

Fig. 1(a). Image in RGB format (Before conversion)

Fig. 1(b). Image in TIFF format (After conversion)

Step 2: Convert TIFF Images into Grayscale

In a color image, each pixel contains three color values, red, green and blue. Converting the color image into grayscale will reduce the number of colors to one. This in turn will reduce the storage size that will result in a decrease in computing time. The conversion was done by using Octave software. Fig. 2(a) shows the original color image and Fig. 2(b) shows the grayscale image.

Fig. 2(a). Leaf image in original color

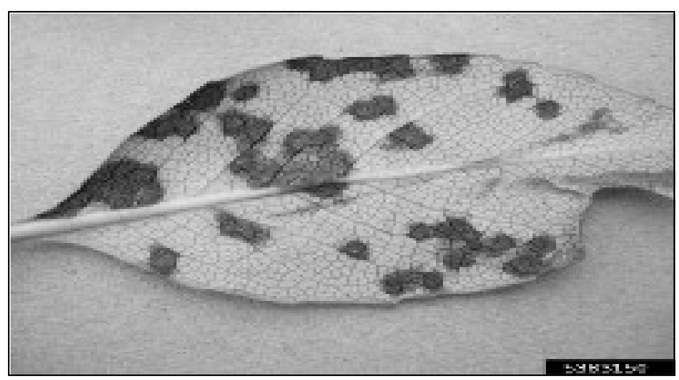

Fig. 2(b). Leaf image in grayscale

Step 3: Data Cleansing

The aim of this step is to filter grayscale images from noises such as dust, blurriness, and unwanted spots. This will produce sharper, smoother and cleaner images [21]. For this process, Gaussian technique was used.

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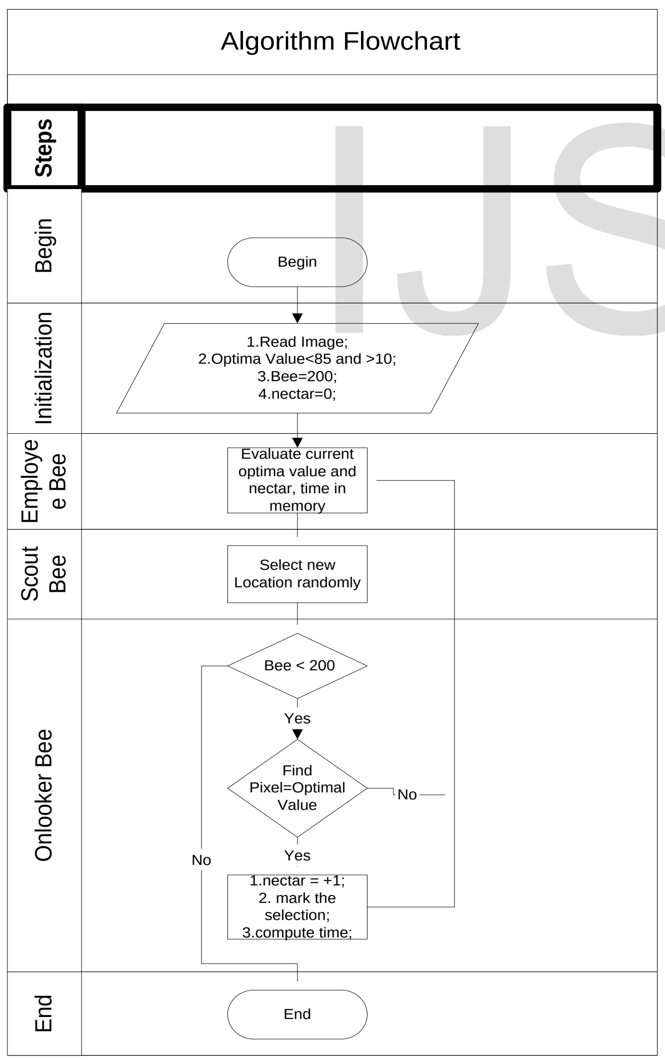
PHASE 2: Construction

In this phase, an algorithm was constructed based on [22]. They had developed an algorithm based on ABC to combine two images into a single image in order to get informative result. This combination is known as image fusion. Their algorithm was adjusted according to this experiment. The adjustments made were: (i) eliminate the step for dividing the image into small windows because in this experiment, whole area in an image was analyzed; (ii) set variable for optima value from 10 to 85 and set amount of bees to 200; (iii) initialize nectar value to zero; (iv) change the step of reading two images (sources) into one image; (v) add time detection step; (vi) change the step using entropy and spatial frequency to determine highest properties to comparing the optima value to get highest properties; (vii) produce blue color mark symbol (+) when bees detect the edge. However, other steps are maintained in this experiment. The algorithm was converted from VC++ 6.0 into Octave 3.2.4. The ABC steps are shown in Table 1.

Table 1. ABC Algorithm Flowchart



PHASE 3: Analysis

The algorithm produced in PHASE 2 was executed on the selected data (grayscale leaf images). The experiment was repeated for four times on each data in order to get a proper output. Every blue color mark symbol (+) was checked to identify whether it is the edge of an object. If it is the edge, then this means that the bees have detected the object. The total number of marks that detected the edge were accumulated and represented as the percentage of correctness. The total number of marks that incorrectly detect an object was also calculated in terms of percentage of incorrectness.

The experiment also captured the time (in millisecond) taken to produce a mark. The time measured was from the start when the algorithm was executed until an edge was detected. In this phase, other detection methods from [23], [15] and [10] will be compared with ABC.

3 RESULTS

The performance of the constructed algorithm was measured in terms of percentage of correctness and detection time (millisecond). Figure 3(a) is the example of original images that was used in the experiment. Figure 3(b) until 3(d) shows the comparison images result for four detection methods. Figure 4 is graph of of correctness percentage in detecting lesions; and Figure 5 is graph average time taken to detect the lesion.

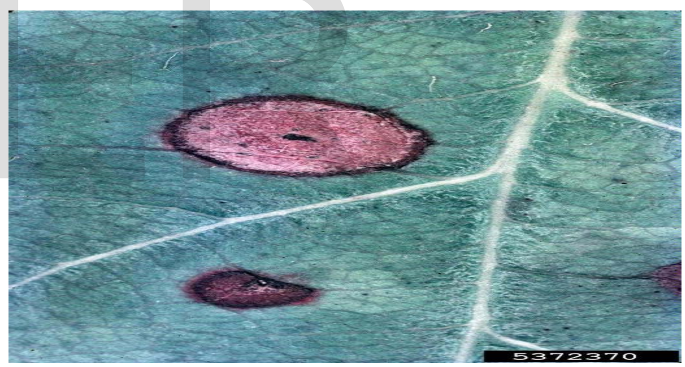


Fig. 3(a). Original Image

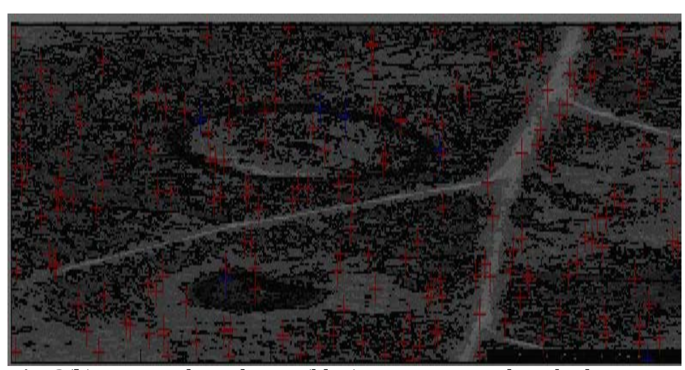


Fig. 3(b). Detected two lesion (blue) using proposed method

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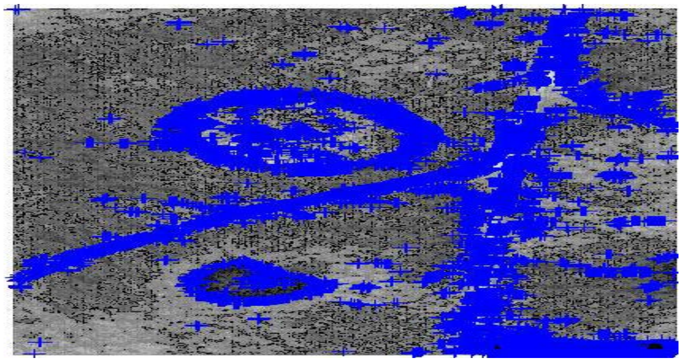

Fig. 3(c). Detected using canny

Fig. 3(d). Detected using sobel, roberts and prewitt

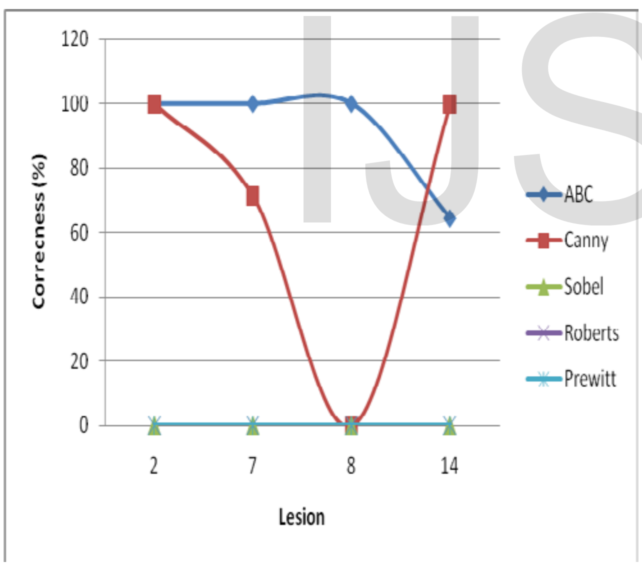

Fig. 4. Percentage of correctness in lesion detection

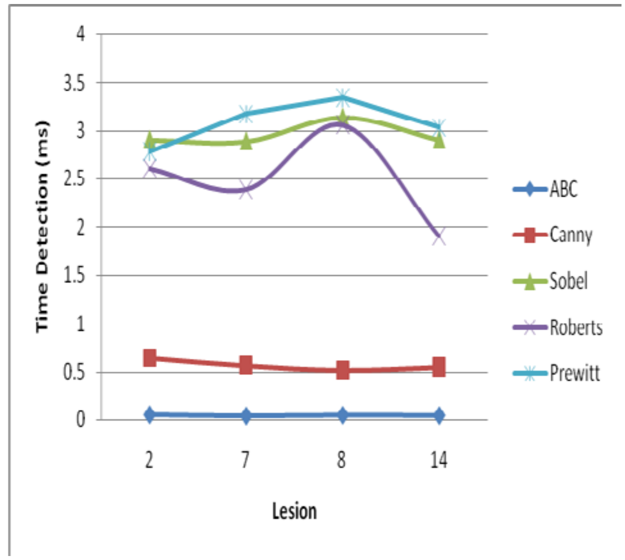

Fig. 5. Time taken to detect all lesions

From Figure 3(b) until 3(d), it can be seen that ABC and Canny could detect lesions correctly, however Canny also detect other objects in the image. Sobel, Roberts and Prewitt could not detect correctly and it is seen like no object exist in the image. In Figure 4 shown that Sobel, Roberts and Prewitt could not detect any lesion. These methods are unable to calculate percentage of detecting correctness and percentage of error in detection.

From all the methods, it shows that ABC was superior to others in detecting lesions of less than ten. However, if the number of lesions is greater than ten, ABC fail to identify all lesions correctly. The reason may be due to the number of bees used in the experiment. That is, the probability of finding an object using two hundred bees is higher when an image has below than ten lesions. If the number of bees is to be increased, then there will be a greater chance of detecting all the lesions. However, the computing time will be increased if the number of bees used is increased.

Canny was able to identify lesions correctly, but the time taken to detect on average was higher than ABC.

4 Conclusions

This study developed an algorithm based on ABC to detect lesions. Four images were tested. ABC and four other edge detection methods were applied to the data. Results showed that ABC could detect lesions faster and more accurately than the other methods. This indicates that ABC could be incorporated into existing object detection algorithms to produce better results.

5 Recommendations

Further experiments using various numbers of bees will be conducted to identify an optimal value. Improvements to the ABC will be made so that images with more than ten lesions can be detected correctly.

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