Image Processing Method for Disease Severity

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***Abstract*-A proper on-time characterization and assessment of disease distribution and intensity could provide useful information for decision making about the timing of fungicide application in precise pest management. In our work severity of brown spot disease is measured with the help of image processing technique. The calculated diseased severity percentage and disease severity scale developed by agricultural scientist Horsfall and Heuberger is helpful to farmers to decide the specific quantity and concentration of pesticide to control the disease which would ultimately reduce the production cost and help to maintain the ecosystem.**

***Keyword*-Binary image, Image segmentation, Brown spot disease.**

I. INTRODUCTION

Detecting plant health conditions plays a key role in farm pest management and crop protection. Pathogens can cause severe damage to crops that often lead to reduced crop yield and quality. The use of large amounts of fungicide can effectively control most crop diseases and decrease the crop production loss. However, pesticide increases costs to growers while environmental problems may be incurred to soil, water, air and ecological systems.

One of the important issues, concerning the sugarcane agriculture management is monitoring and controlling of the diseases. For example fungi-caused diseases in sugarcane are the most predominant which appear as spots on the leaves. These spots prevent the vital process of photosynthesis and hence, to a large extent it affects the growth of the plant and consequently the yield. In case of severe infection, the leaf gets totally covered with spots impacting a loss of yield [12].

One may suggest the use of pesticides but excessive use of pesticide against the protection of disease, however, increases the cost of production and results in environmental degradation [23]. This drawback can be removed by estimating severity of the disease and targeting the diseased places, with the appropriate quantity and concentration of pesticide.

Traditionally, the naked eye observation method is used in the production practices to measure the severity of disease. However, the results are subjective and are not possibly used to measure the disease precisely [24]. Grid counting method can be used to improve the accuracy of estimation but it is a cumbersome and time consuming procedure.

Plant disease symptoms can be measured in various ways [26] that quantify the intensity, prevalence, incidence and severity of disease.

1) Disease intensity is a general term used to describe the amount of disease present in population.

2) Disease prevalence is the proportion of fields, countries, states etc. where the disease is detected and reveals disease at grander scale than incidence.

3) Disease incidence is the proportion or percentage of plants diseased out of a total number assessed.

4) Disease severity is the area (relative or absolute) of the sampling unit (leaf or fruit) showing symptoms of disease. It is most often expressed as a percentage or proportion.

II. ANALYSIS AND DESIGN

In this work disease severity measure has been considered particularly for brown spot diseased sugarcane leaves.

Brown spot is a fungal disease which causes reddish-brown to dark-brown spots on sugarcane leaves. The spots are oval and circular in shape, often surrounded by a yellow halve and are equally visible on both sides of the leaf [12]. The long axis of the spot is usually parallel to the midrib. They can vary from minute dots to spots attaining 1 cm in diameter.

The disease severity of the plant leaves is measured by counting the number of pixels and defined as the ratio of number of pixels in diseased region and total pixels in leaf region [28]. It is expressed as below:

Disease Severity,

$$S = \frac{A_d}{A_l} \qquad (1.1)$$

Where, A_d -Diseased leaf area,

A_l -Total leaf area.

Here,

$$P_d = \sum_{(x,y)\in R_d} L(x,y) \qquad (1.2)$$

$$P_l = \sum_{(x,y)\in R_l} L(x,y) \qquad (1.3)$$

$$S = \frac{P_d}{P_l} \qquad (1.4)$$

Thus,

$$S = \frac{\sum_{(x,y)\in R_d} L(x,y)}{\sum_{(x,y)\in R_l} L(x,y)} \qquad (1.5)$$

Where, L- Leaf image,

P_d -Total pixel in diseased region,

P_l -Total pixel in leaf region,

R_d -Diseased region and

R_l - Leaf region.

In sugarcane agronomy it is experimental that the length and width of leaf vary upto 1.5 meter and 3 inches respectively. To cover the whole leaf area in the image, the distance between camera and leaf is adjusted proportionally. This tends to reduce the resolution of image and cause poor segmentation of diseased part of the leaf. Consequently to increase the accuracy of measurement of disease severity, the leaf is cut into the pieces. Another important subject in image capturing is that the evaporation rate of sugarcane is 150 to 200 times faster than other plants. Therefore sugarcane leaf tends to wrinkle directly after it is separated from the stalk. So, it is advised to capture the images quickly (without delay). The experimental setup to capture the image of diseased leaf is shown in the Figure 1.1.

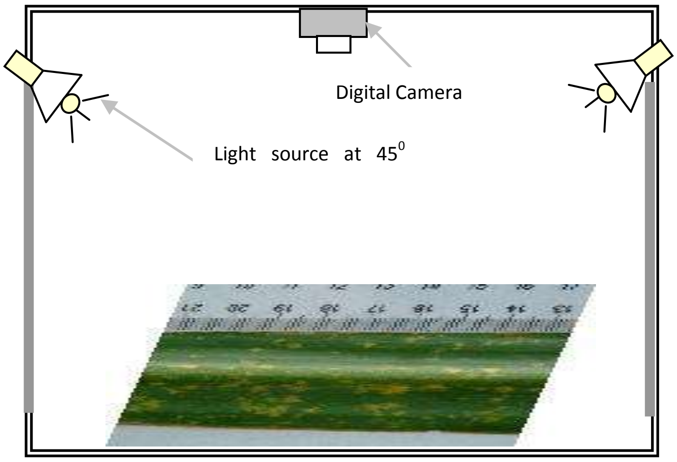

Figure 1.1: Experimental set up for capturing disease leaf images

III. IMPLEMENTATION

To calculate the brown spot disease severity of sugarcane leaf the designed algorithm is as follows:

A. Acquire the image of diseased leaf

B. Preprocessing of image to convert in proper format.
C. Segmentation of leaf region.
D. Computation of leaf area
E. Segmentation of diseased region
F. Computation of Diseased area
G. Computation of the percentage diseased severity using diseased area and leaf area.

A. Acquire the image of diseased leaf:

The following describes the experimental set-up that was used for image acquisition.

1) The leaf with reference objet coin was placed on a light panel so that the spots become more visible.

2) Light sources of cool white fluorescent light were placed at 45^0 on each side of the leaf so as to eliminate any reflections and to get even light everywhere.

3) The camera was placed just above the leaf so as to get a better snapshot.

4) To distinguish objects in an image an easily separable background is essential and hence white background was used in this experimentation.

The sample image of diseased leaf is shown in Figure 1.2. This image is used for further processing.

Figure 1.2: Original image of diseased leaf

B. Preprocessing of image:

These steps convert input sample image in more suitable format for the segmentation.

1.Re-size the image:

A digital camera used for capturing image was 12 mega pixels, input colour image size is 4000 × 3000, this image is down sampled to 256 × 256 for low processing time. The down sampling of an image is performed by the process of the interpolation [26]. The resized colour image is used for gray scale conversion.

2. RGB to Grayscale conversion:

To reduce the complexity of obtaining leaf region and region of interest, background should be removed first therefore input image is converted to the grayscale intensity image. The input colour image is converted to gray scale using equation (1.6) is as below:

$$I = 0.3R + 0.59G + 0.11B \qquad (1.6)$$

For proper contrast, the image of diseased leaf was taken on white background results into large difference in gray values of two region i.e. leaf region and background. This gray scale image is, shown in figure 1.2, further used for separating leaf region from the background.

Figure 1.3 Gray scale image of diseased leaf

C. Image segmentation:

In many vision applications, it is useful to isolate the regions of interest from the background. The level to which the subdivision is carried out depends on the problem being solved. That is, segmentation should stop when the objects of interest or the regions of interest in an application have been isolated. Thresholding techniques for segmentation were used [25].

In this section two different thresholding techniques were implemented to obtain total leaf region pixels and pixels of diseased region of leaf. Brief understandings of these techniques are as:

1.Leaf region Segmentation:

To count the total pixels in leaf region they must be separated from the background. The use of histogram to separate the region is a common practice.

Thresholding technique is used to separate the leaf region form the background. Largest value of co- variance is selected as threshold value. For the sample image threshold value comes out to be 0.9 and resultant binary image for the same is shown in Figure 1.5.

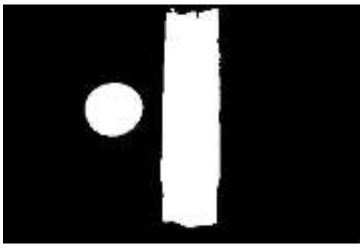

Figure 1.5: Binary image of diseased leaf

D. Computation of leaf area:

To count the total white pixels in leaf region (R_l), the binary image is scanned in top-down format. The number of white pixels in the white non-zero region is counted using equation (1.3), $P_l = \sum_{(x,y)\in R_l} L(x,y)$. The leaf pixels count for the sample image comes out to be 19242.

E. Disease region segmentation:

The accurate segmentation of disease region determines the success or failure of the experiment. As the diseases characteristics varies the boundaries between diseased and healthy part of leaf also varies which results in a weak edge.

Another problem is the presence of boundary objects. The boundary objects are not complete and thus may hinder the process of accurate segmentation therefore the boundary objects have to be removed. Hence thresholding method is used in this experiment. By using thresholding gray scale image converted into binary image with intensity level of 0 and 1. A disk shaped morphological structuring element is created with a width of 30 pixels. The binary image is subjected to series of morphological operation.

Using the resultant threshold, 'H' component of the HSV image is threshold to convert the Hue image into binary image

Further, this binary image is morphologically processed to fill holes in the binary. A hole is a set of background pixels that cannot be reached by filling in the background from the edge of the image. Thus the resultant image is one that would not have noise pixels at boundary, as shown in Figure 1.6.

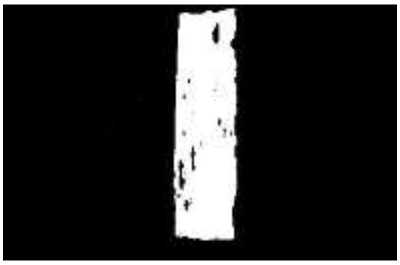

Figure 1.6 : Filtered image of diseased leaf

F. Computation of diseased area:

For the sample image shown in figure 5.19 the pixel count of diseased region image (R_d) is given by equation (1.2), $P_d = \sum_{(x,y)\in R_d} L(x,y)$ and is come out to be 4114.

G. Computation of the percentage diseased severity using diseased area and leaf area:

Disease severity is calculated by using equation ,

$$S = \frac{\sum_{(x,y)\in R_d} L(x,y)}{\sum_{(x,y)\in R_l} L(x,y)}$$

The measured disease severity is expressed in a more quantitative way by using disease severity scale developed by agricultural scientist 'Horsfall and Heuberger' [26]. They developed early interval scale, which is still widely perceived as a way to save time in disease assessment. A score of disease in plants is calculated and rated on the scale. Thus according to Table 1.1 disease severity of sample image is of category 1

Category	Severity
0	Apparently infected
1	0 – 25% leaf Area infected
2	26-50% leaf Area infected
3	51-73% leaf Area infected
4	>75% leaf Area infected

Table 1.1- Disease severity scale developed by Horsfall and Heuberger

IV. RESULTS AND DISCUSSION

This section describes the detailed test strategies and the results obtained. A total of 25 diseased leaves are tested using this algorithm.

V. CONCLUSION

Disease symptoms of the plant vary significantly under the different stages of the disease. Hence the accuracy depends to some extent upon segmentation of the image. Otsu threshold segmentation can be used for leaf region segmentation but this thresholding method is not suitable to disease region segmentation because of varying characteristics of the disease. The average accuracy of the algorithm is tested using known area diagram and is 98.60 %. This indicates that the designed algorithm can measure the disease severity of the leaf more accurately.

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