Development of a web based system to practice the estimation of plant disease severity

Daminda T. Andrahanndi[1], He Dong Jian[2], Wang Mei Li[3]
[1]*Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya 81100, Sri Lanka*
[2]*College of Mechanical and Electrical Engineering, North West A&F University, Xianyang, China*
[3]*College of Information Engineering, North West A&F University, Xianyang, China*

***Abstract*- Identification of disease severity at the correct stage plays an important role in the maintenance of a healthy cultivation. Sometimes, farmers apply chemicals unnecessarily causing both health and environmental hazards. It is important to avoid such mal-practices by improving the awareness of farmers. Disease severity is the critical factor to take a decision on pesticide application. In most of the cases, farmers try to go for visual estimation by their own without the assistance of expertized officers. Accordingly, it is necessary to train farmers and other interested parties on estimation of the disease severity. This research aims to develop a web site to allow stakeholders to practice and improve their skills on estimation of disease severity. In this research image processing techniques were applied for the calculation of leaf area and then calculated the disease severity using these estimates. Increased availability of cameras and other devices with embedded cameras thrive the adaptability of digital image processing. Digital images of infected leaf samples were input to the system and open source software image j was used to calculate the total leaf area and infected area. Disease severity was estimated using these values and they were stored in a database. Data base was created with MySQL and it was link with the website using php. Web site was created using html, php and Java scripts. Login accounts were created for individual users and they were allowed to logon to the system using their accounts. Then, they can practice the estimation of diseases using the sample images available in the web site. First, user has to feed the estimated value according to him and then the system will provide the accurate value of disease severity. Users are facilitated to ask any number of samples according to their desire. Accuracy of the algorithm was tested by comparing the obtained values with the grid count method. Accordingly, average accuracy of the estimation of disease severity is 96.12% and it is better than the traditional approach since it is faster and machine oriented.**

***Index terms*- Grid method, image processing, leaf area, plant disease severity**

I.INTRODUCTION

Plants have to survive against both biotic and abiotic stress factors in the environment. Plant disease is one of the most common stress factors among them [23]. Plant diseases cause weakening of the normal physiology of a plant and interferes its various functions. [9]. Plant diseases produce various types of symptoms in the field. For the accurate diagnosis various terms are in use to define the symptoms in the diseases [20]. These symptoms appear as chlorosis (yellowing) and necrosis (browning and death) of the leaves and stems in many diseases. Accordingly, photosynthesis is mainly affected by the plant diseases. Since it is the most essential function of plants, even a slight modification of photosynthesis deteriorates the plant and increases susceptibility to other pests and pathogens. Even a slight modification of photosynthesis deteriorates the plant and increases susceptibility to other pests and pathogens [7].

Both qualitative and quantitative reduction of crop production occurs annually, due to this susceptible nature. Therefore, it is a great challenge to ensure the global food security [17]. Accurate identification is a difficult task and it is inefficient due to various reasons. Visual assessment by naked eye observation is the widely used approach in the world for detection of diseases [3, 18]. The problems of identifying plant diseases by the naked eye are inefficiency, time consuming, requirement of expertise on plant diseases and high cost or lack of facilities to reach experts [22]. Moreover, there is a high subjectiveness arising from different individuals [10]. Farmers have

to search for the advice of experts to treat pest and disease incidences. In such cases, some farmers have to travel long distances to reach experts. It is time consuming. Sometimes the experts are may not be able to provide a sufficient answer with the accessible information from farmer. Sometimes seeking expert advice may be expensive [13]. In some situations, farmers try to estimate the diseases using their own experience without any scientific approach [21]. If inaccurate disease severity assessment happened, wrong conclusions and inappropriate management practices would be applied [3].

There is a high demand for computer based method for extraction and analyzing of a significant content of the diseases. Using visible wave length of the digital images is one way of integrating computer techniques to quantify plant diseases and it has advantageous properties comparative to the visual assessment [3]. Digital image processing plays an important role in this scenario to overcome many difficulties [10]. In this approach, computer algorithms are used to perform the processing of digital images to acquire more information [21]. Here, image processing techniques were applied for the calculation of leaf area [22]. Many researches in literature were targeted on the estimation of disease severity.

Sarah J. et al in 2015, has developed A New Portable Application called Leaf Doctor for Quantifying Plant Disease Severity. They investigated for tan spot of lima bean, downy mildew of collard, gummy stem blight of water melon, foliar disease complex of tomato and powdery mildew of lilac and achieved an accuracy of 94 percent through image processing. However its limitation is the requirement of a black background to capture the image [19].

Guan Wang et al. (2017) has developed Automatic Image-Based Plant Disease Severity Estimation Using Deep Convolutional Neural Network with a comparison of VGG16, VGG19, Inception-v3 and ResNet50 architectures. They categorized each sample as healthy stage, early stage, middle stage and early stage according the severity of the disease. Severity of apple leaf black rot caused by the fungus Botryosphaeria obtuse has estimated by fine-tuned VGG16 model performs achieving an accuracy of 90.4 percent [8].

Nikita K. A. and Deore P. J. (2015) mentioned that missing parts may be available in the leaves due to pest and disease attacks and she pointed out the importance of filling missing parts for area calculation in leaf analysis. Contour extraction and region filling techniques were adapted in such cases [11].

Like most of the other method, Sena Jr D.G et al. converted RGB images into grey scale images and assumed mean threshold of foreground and back ground as the optimum threshold. Maize plant leaves have separated from the background image by assigning zero to the pixels representing leaves and one for the background. However, they were developed an algorithm only for the identification of infected plants [6].

Rashedul I. and Md. Rafiqul I. applied k means clustering for calculating disease affected leaves of paddy and achieved a 100 percent accuracy of counting the pixels [16]. In 2018, Sethy P.K et al. followed the same procedure of K- means clustering as Rashedul I. and Md. Rafiqul I, to segment the images. They had added additional step by introducing a grading system as per the amount of infection by applying Fuzzy logic. This system demonstrated the disease severity of brown spot, bacterial blight, leaf scald and leaf blast of rice with 86.35 percent of accuracy [15]. Sachin.B.J. (2015) also followed the k means clustering procedure for grey scale images based on the squared Euclidean distance for bacterial leaf blight, septoria brown spot and bean pod mottle virus infected soybean leaves. Further, they pointed out this method is capable of recording disease severity with high precision in a low operating time [1].

As per the findings of Wijekoon CP et al. (2008) disease severity can be estimated without using programming techniques for segmentation. In this research, Scion Image software which is freely available has used for the purpose of digital image analysis to estimate the disease severity. Further, brightness and contrast of the images were increased using Paint Shop Pro 7 software to increase the difference between healthy region and infected pustules except rust of S. Canadensis [4].

Dominic Asamoah et al. (2017) have represented the background in black colour and the leaf region in white colour considering the variation in grey scale. MATLAB software has used for the calculation of

leaf area. Histogram of hue area has taken into account to determine the healthy and infected regions and it considers as healthy, if hue value is fallen between 0.15 and 0.5 and infected otherwise. Disease severity has estimated by counting the pixels in each area. This method has proved an accuracy of 97 percentages [5].

Sanjay B. Patil and Shrikant K. Bodhe elaborated triangle thresholding method to estimate thebrown spot diseases in sugarcane leaves. Using which overcome the weakness normal thresholding method. Then the grey value in midrib has made similar to the normal leaf colour to minimize its interference to the estimation of infected lesions. The accuracy of estimated areas were tested using standard known area shapes like triangle, circle, square and rectangle created using computer aided software and pointed out an average accuracy of 98.6 percent [2].

A slightly different method from the above one has designed to find disease severity. RGB images of cassava brown leaf spot have converted into HIS and the intensity component has separated using Otsu's method. The researchers have compared the new approach with the manual method with manual scoring using Teri's diagram key. They found that there is a high correlation (R2=0.9) between the method of image analysis and manual method [12].

However, it was not possible to find the researches that had been conducted to estimate the severity of plant disease for species that are mostly cultivated in Sri Lanka. Further, a previous attempt to develop a website is not available for practicing the estimation of plant disease severity through image processing. Therefore, this research aims to develop a web site to fill that gap and allows users to practice the disease severity estimation. Accordingly, this would be much helpful for improving the skills of farmers and other interested parties on disease estimation and ultimately, overcome the yield loss. Another objective is to focus more on common diseases among mostly cultivated plant species in Sri Lanka. Depending on the success of it, the research would be expanded to build a platform to share the opinion of users on the topic.

II. METHODS

As the first step of digital image processing, the samples of infected leaves were collected from randomly selected fields identifying the disease accurately and then image processing techniques were applied to extract necessary information for analyzing purposes. The steps of developing the web site can be summarized as in the figure 1.

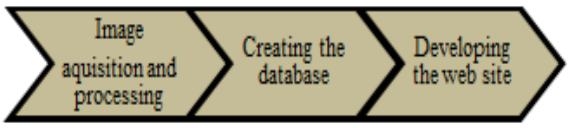

Fig 1. Steps of developing the website for estimating the disease severity

Image pre-processing: Pre-processing of plant leaf images is applied to remove the noise from the image. The image is enhanced in the preprocessing step by image clipping for removal of the background, image smoothing using a smoothing filter and image enhancement for increasing contrast.

Image acquisition and processing: Samples of normal leaves and infected leaves were collected from randomly selected fields identifying the disease accurately. The leaves were placed in a white background and the camera was placed horizontally with the plane of the leaf. Then RGB images were captured by a digital camera under the disabled flash mode and fed them to the system in JPEG format. Then it was processed using an open source software; ImageJ.

During the image processing, image segmentation was one of the critical tasks and is the most important step. Infected leaf area and total leaf area were estimated using this software with necessary image editing techniques. Thresholding option provided by the software was applied for the segmentation of leaf regions. The disease affected region of the leaf is segmented into a number of parts to demarcate the boundaries and it was indicated by a different colour. Disease affected portion was isolated by this area. The boundaries of the leaf were extracted from its background to calculate the total leaf area. These extracted areas were used for the estimation of disease severity. According to the following formula disease severity is the area of plant leaf with the symptoms.

$$\text{Disease Severity} = \frac{\text{Infected leaf area (pixels)}}{\text{Normal leaf area (pixels)}} \times 100\%$$

Creating the database: The database and necessary tables were developed with the MySQL software and processed data in above steps were fed to the database. The database consisted with the name of the disease, causal agent, samples which used as the trained data set and their estimated disease severity, same samples as the testing data set. The images of all the infected samples of all the diseases were processed as in the above figure. About 80% of leaves were used as the training data set and remaining 20% was used as the testing data set.
Then, a macro was created for this task and saved for future references within the webpage. Macro was uploaded to the web allowing to run it within the webpage through php.

Developing the website: Website was developed using html, php and Java scripts. Created database was linked with the webpage using php. User accounts were created for interested stakeholders and login information was provided to them. A list of plants display in the interface and the users can be noticed it after login to the system. Then they have to select the plant species which they are intended to practice the estimation of disease severity. Further, they allow to select the number of samples they are willing to use for practicing. After selecting these things, infected samples will be displayed and user is allowed to enter his estimation and then system provides the exact estimation considering the fed data set in the database. With this experience, user can see the deference between estimate the disease severity and actual disease severity according to the fed dataset provided by the system.
This method was applied for the diseases in selected three plant species as in the table 1.
Table 1: Selected plant species and their diseases

Plant species	Disease
Pumpkin	Alternaria Leaf Blight Disease
Okra	Leaf Spot Disease
Long bean	Leaf Spot Disease

III. RESULTS AND DISCUSSION

Captured photograph shown in Figure 2-4 (a) was processed by Images to obtain a bi-colour image. The output in Figure 2-4 (b) represents the separation of infected and non-infected area as green colour healthy region and red colour damaged area. Figure 2-4 (c) was created to obtain the total leaf area.

Fig 1: Sample leaf images of pumpkin alternaria leaf blight (a) Input image (b) Infected leaf area (c) Total leaf area

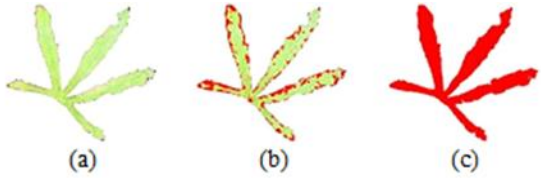

Fig 3: Sample leaf images of okra leaf spot (a) Input image (b) Infected leaf area (c) Total leaf area

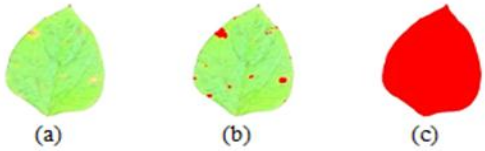

Fig 4: Sample leaf images of long bean leaf spot (a) Input image (b) Infected leaf area (c) Total leaf area
Various statistical methods were used to test the quality of image analysis measurements compared with true and estimated values for disease severity, accuracy and precision of the estimates and repeatability and reproducibility of various methods. Regression analysis is the most commonly used tool for the above purposes.

Accuracy:
Further, a comparison was done between the estimated disease severity by the image analysis and visual estimation by grid method. Grid method was selected for comparison which is one of the most reliable methods applying for leaf area calculation. Even though it is accurate, it becomes laborious and time consuming, when going for the application in large scale. Following equation was used to estimate the percentage of error of proposed algorithm as in the experiment conducted by Piyush Chaudhary in 2012. Where, Dg is the Disease Severity obtained by Grid Method and Di is the value calculated by image processing techniques.

$$\text{Percentage of Error} = \frac{D_g - D_i}{D_g} \times 100\%$$

Plant species	Disease	Disease Severity		Error percentage of Image Analysis	Estimation accuracy % by Image Analysis
		Digital Image Analysis	Visual Estimation by grid method		
Pumpkin	Alternaria leaf blight	14.2116	14.2448	1.10	98.9
Okra	Leaf spot	29.4654	30.0485	2.28	97.72
Long bean	Leaf spot	4.5469	4.9801	8.25	91.75

Table 2: Accuracy of the estimation of Disease Severity

It was possible to estimate the detection accuracy as a percentage by using the above error values. Detection accuracy is represented in the table 2. According to the table this approach was highly appropriate for estimating the pumpkin alternaria leaf blight disease with an accuracy of 98.9%. The accuracy was moderately low for leaf spot disease of long bean. The infected area of the disease is comparatively small and these spots were scattered all over the leaf. This may be the reason for low accuracy of the detection of long bean leaf spot (Table 2).

Further, estimates of disease severity by image processing and grid method for the same samples were highly similar with a significant linear relationship ($p<0.0001$) for all the diseases evaluated under this study (Table 3).

Relationships between disease severity estimated by the proposed method which used pixel count (independent variable) and the estimation made using millimeter graph paper method (dependent variable) for three plant species are given in Table 3. In the regression equation, Y is the Disease Severity estimated by grid method and X is the Disease Severity calculated by image processing. According to the coefficient of determination (R2) values of pumpkin, okra and long bean as 89.5%, 98.3% and 96% respectively, the total variation in the severity of grid method can be explained by the proposed method. This higher value indicates a higher precision or reliability of the estimated values. Further, a higher proportion of variability could be explained by the regression model. Therefore, severity estimates of computational techniques are applicable in place of grid method in large scale practical cases.

Table 3: Regression equations and coefficients of determination between leaf area measured by image processing and that estimated by grid method for three plant species. Observations were made on attached leaves. (All values are significant at $p<0.05$)

Species	Regression Equation	R^2	Probability
Pumpkin	Y=1.038X-0.502	0.895	0.015
Okra	Y=0.913X+3.159	0.983	0.001
Long bean	Y= 1.118X-0.105	0.960	0.003

IV. CONCLUSIONS

According to statistical analysis, proposed algorithm is accurate and precise for the estimation of disease severity. The tested algorithm was proved an average accuracy of 96.12%. The experimental results indicated that the proposed approach is applicable for the estimation of disease severity with a little computational effort. It is important for educational and research purposes. Further, the practical application of this website support farmers to take decisions on pesticide application within the economic threshold level, reducing the environmental pollution through preventing unnecessary applications.

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