Advances in Computational Research
ISSN: 0975-3273 & E-ISSN: 0975-9085, Volume 7, Issue 1, 2015, pp.-265-267.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000187

SOYBEAN RUST SEVERITY MEASUREMENT USING IMAGE PROCESSING TECHNIQUE

SOMWANSHI D.R.[1] AND HUMBE V.T.[2]*

[1]Department of Computer Application, College of Computer Science & IT, Latur - 413 531, MS, India.
[2]School of Technology, SRTMU Nanded, Sub-Center, Latur - 413 531, MS, India.
*Corresponding Author: Email- vikashumbe@gmail.com

Received: December 18, 2014; Revised: January 05, 2015; Accepted: January 15, 2015

Abstract- Soybean rust is the most harmful type of soybean crop foliar disease. For diagnosis & detection of rust, expert and naked eye observation is required and in the process of controlling the rust infection it is necessary to calculate the severity of the disease infection, this research paper provides the accurate method of quantification of rust severity through color segmetation method. Red (R) Green (G) Blue (B), Hue Saturation Intensity (HSI), Hue Saturation Value (HSV) Color Spaces are studied as part of the research and demonstrated HSI Color space based approach provides the best result. Manual threshold setting method is used, and it is found suitable for quantification of rust infection. Ratio of Infected Area (RIA) is calculated for accurately quantification of soybean rust area or the percentage of area affected by the soybean rust.

Keywords- Quantification, Severity, Hue Saturation Intensity, Hue Saturation Value, Ratio of Infected Area

Citation: Somwanshi D.R. and Humbe V.T. (2015) Soybean Rust Severity Measurement using Image Processing Technique. Advances in Computational Research, ISSN: 0975-3273 & E-ISSN: 0975-9085, Volume 7, Issue 1, pp.-265-267.

Introduction

Providing solution to agriculture problem is important because everyone depends upon agriculture for survival. Plants/crops are the important source of energy. Near about 60% population of India depends upon the agriculture [1], which is the primary source of their income and it is important sector in economy of India. Science and technology plays the important role in increasing the agriculture income of the farmer and indirectly the income of the nation.

Diagnosis of the disease which has visual symptoms requires the expert's analysis or at least first guess about the disease is performed visually by humans or experts person or trained person because such disease generates some kind of appearance or sign in the visual spectrum. But there are some disadvantages of such trained eye or experienced plant pathologists or trained person or expert person [3] as listed below.

- They may tire and lose concentration, thus decreasing their accuracy.
- There can be substantial inter- and intra-rater variability (subjectivity).
- Training may need to be repeated to maintain quality. Raters are expensive.
- Visual rating can be destructive if samples are collected in the field for assessment later in the laboratory.

Various technologies have been developed in recent year for automatic detection of plant diseases. It is now possible to identify the type of disease affected to that plant by using image processing (for segmentation of disease affected area) and neural network based technique (for classification of disease).

In 2007 Kuo-Yi Huang. presented the application of neural network & image processing technique for detection and classification of Phalaenopsis seedling diseases. They segmented the disease affected area by using exponential transform with adjustable parameters. They further used Gray Level Concurrence Matrix (GLCM) to evaluate the texture features of lesion area.

In 2009 Di Chi, Qin Zhang et al presented the feasible method soybean rust detection & its severity measurement, they have collected the image database using CDD camera, and reported different forms of vegetation indices of rust severity.

In 2010 again Di Chi, Qin Zhang et al showed the fast manual threshold setting method based on HIS color space is most suitable for segmentation of rust infected area and calculation of rust infected area in percentage.

In 2012 Baoshi Jin et al identified the method of division algorithm and eigenvalue computation and they have designed a three level neural network model to identify the diseased spot area.

Here we also wanted to contribute to this by providing some technological accurate and fast solution to disease detection in agriculture field.

For this we have chosen soybean crop for our study, we wanted to study different soybean disease and wanted to provide analysis, diagnose and the accurate prediction about different soybean diseases. But to reduce the complexity of study we have chosen only a single disease called soybean rust and succeed to identify its severity.

Soybean is one of major cash crop in India, and many other countries such as China, Taiwan, Japan, Thailand, United States of America and more than 39 such countries in the world [2].

Soybean rust is one of the most critical or harmful diseases of soybean. Production of soybean in Asia undergoes significant yield losses since 1960s [1]. It has been reported that this disease causes 10-40% yield loss in Thailand, 10-90% loss in India, 10–50% loss in Southern China, 23-90% loss in Taiwan, and 40% loss in Japan [2]. Soybean rust has now occurred in at least 39 countries in both Eastern and Western hemispheres [2-4].

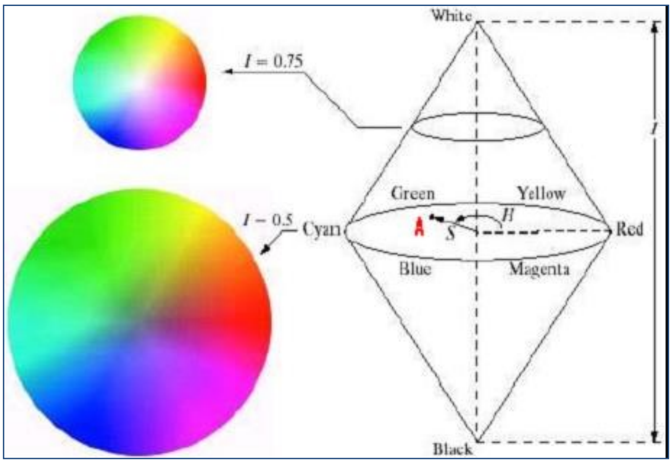

Fig. 1- HIS Color Model Illustration

In the United States, soybean rust was first detected at Louisiana State University Ag-Center Research Farm in 2004 [5]. Soybean rust has now been found in most soybean-producing states in the continental United States. Soybean rust disease is mainly caused by two types of fungi, *Phakopsora pachyrhizi* and *Phakopsora meibomiae*. *Phakopsora meibomiae* is the weaker pathogen than *Phakopsora pachyrhizi* and generally does not responsible for widespread problems [2].

Because Soybean rust is one of the foliar disease it create copies amount of spore that affects the other soybean plant. Such spore spreads over all the soybean plant in the field. To control in timely manner and to apply the adequate pesticides to control the disease there is need to determine the severity that means there is need to calculate accurate identification of how much it is infected or the lesion area of disease affected leaves of plant.

Major symptoms of soybean rust that is seen on leaves of plant is, color of plant leaves shown as gray green to tan & finally dark brown or reddish brown. Such symptoms have shown in large at bottoms leaves of the soybean crops, and less towards the top leaves of the soybean crops.

Methodology and Procedure

Image Acquisition System and Database Description.

The diseases infected soybean crop databases were downloaded from http://www.uaex.edu/yard-garden/resource-library/diseases/soybean accessed 14-May-2014. On this website sample images of all types of soybean disease we found. This database is maintained by Division of Agriculture, Research & Extension, University of Arkansas, and Cooperative Extensions Services. This database contains images of near about all types of disease infected soybean crops images. A multispectral CCD camera was also used for Soybean leaf images acquisition in this research.

Selection of Color Space

Images that is collected from the database and captured from camera are the color images which contain the red, green & blue band of images; each pixel in the image is a mixture of red, green and blue value. Segmentation of gray green to tan and dark brown or reddish brown area using RGB image is somewhat time consuming and the result is not that much accurate. Natural way of classifying the colors of an image or object or pixel is based on Hue (H), Saturation (S), and brightness or Intensity (I), instead of R, G, and B value of image or object or pixel. Another way of classifying the colors is based on Hue (H), Saturation (S), and Value (V). Our assumption in this research work is that HIS or HSV is more accurate and better which increase the speed of color classification as compared to RGB Color model.

So we have first convert the RGB image HSI Color Space by using the following equations set given in Gonzalez & Woods,2002, PP 292. according to [Fig-1].

$$H = \begin{cases} \theta & \text{if } B \le G \\ 360 - \theta & \text{if } B > G \end{cases} \quad (1)$$

$$\theta = \cos^{-1}\left\{ \frac{\frac{1}{2}[(R-G)+(R-B)]}{\left[(R-G)^2+(R-B)(G-B)\right]^{1/2}} \right\} \quad (2)$$

$$S = 1 - \frac{3}{(R+G+B)}[\min(R,G,B)] \quad (3)$$

$$I = \frac{1}{3}(R+G+B) \quad (4)$$

Where R, G, B are the Red, Green, and Blue Image Components, these components need to separate from RGB Image.

Following figure shows how RGB point can be converted in to HSI Point. In the figure point A is a color point & whose angle from the red axis gives the hue value.

The length of the vector represents the saturation level this value normally ranging between [0, 1]. The Intensity range is between [0, 255] but this have been normalized to the range [0 1] with 0 representing black and 1 representing white.

The hue is represented within [0°, 360°], with 0° represents red, 60° yellow, 120° green, 240° blue and 300° magenta. This information of color degrees in HIS Model can easily be used for image segmentation, here we have to separate healthy and infected area of rust infected soybean image. As mentioned earlier color of rust infected image is from gray green to tan and dark brown or reddish brown. So this hue angle can easily be used for segmentation of this area. We can easily specify the threshold to segment the infected area.

Image Processing Procedure

We have collected the different level of rust infected soybean leaf images such as severe, medium, less, invisible infections. Then those images are formatted using Photoshop 7, as per the requirement. Means we have cropped the unwanted parts from images, and only keeping the leaf image. We have implemented the following procedure.

- Acquire the Rust infected RGB Image,
- Separate the R, G, and B Components from RGB Image.
- Convert RGB Image into HSI Image using [eq-1,2,3,4].
- Separate the H, S, and I Components from HIS Image.
- Apply 3X3 median filter for Image Enhancement
- Separate the infected, healthy background pixel using [eq-5]
- Separate the gray green to tan & dark brown pixel using [eq-6]

To segment the infected pixel there is need to implement the formula that will identify the infected pixel. Using the HSI Color model the gray green to tan and dark brown or reddish brown area lies in 0º to 90º and 330º to 360º, a threshold can be selected as per the accuracy of result & from invisible infection to severe infection identification. Threshold can be selected between 20º and 90º, here we have selected the threshold value is 80º for segmentation of infected area from invisible infection to severe infection.

$$\begin{cases} In(i,j) & if\ H(i,j) \geq 0^{\circ}\ and\ H(i,j) \leq Ht^{\circ}\ or\ H(i,j) \geq 330^{\circ}\ and\ H(i,j) \leq 360^{\circ} \\ if\ Hy(i,j) & if\ H(i,j) \geq Ht^{\circ}\ and\ H(i,j) \leq 150^{\circ} \\ Bg(i,j) & else \end{cases} \quad (5)$$

Again for calculation or separation of gray green to tan area & dark brown to reddish brown area we have modified the formula presented by Di Cuia et al. [5].

$$\begin{cases} BrownArea(i,j) & if\ H(i,j) \geq 0^{\circ}\ and\ H(i,j) \leq 60^{\circ}\ or\ H(i,j) \geq 330^{\circ}\ and\ H(i,j) \leq 360^{\circ} \\ if\ GrayGreenArea(i,j) & if\ H(i,j) \geq 60^{\circ}\ and\ H(i,j) \leq 80^{\circ} \end{cases} \quad (6)$$

Here we have selected the threshold value is 60º for brown area segmentation, and 60º to 80º are used for gray green to tan area segmentation.

Severity and Infected area Calculation

For Ratio of infected area we have implemented the following formula. RIA=(Sum(In)/Sum(Hy))*100 (7).

Result & Discussion

The first method we have implemented for rust analysis is that, separation of leaflet images from background pixel and cropping unwanted part. To Convert the RGB Image into HSI Image we have separated R, G, B band from RGB image, then using [eq-1,2,4]. We have converted RGB Image to HSI color Space. After that we have separated, Hue, Saturation, and Intensity component from RGB Image. Then we have separated infected image and healthy image from Hue (H) Image using [eq-5,6] respectively. For separation of infected area we have selected high threshold value as 80º. Again we have also separated gray green to tan and reddish brown or dark brown area pixel using [eq-7,8] respectively. Threshold value for gray green area separation we have selected is 60º and for reddish brown or dark brown area we have selected between 60º to 80º. Ratio of infected area is calculated using [eq-9], [Fig-2].

Threshold value that we have selected gives the best result for all type of rust infection. i.e. from invisible severity to high severity.

Conclusion

In this paper we have studied the different color model for image segmentation of soybean rust disease infected leaves, and conclude that Hue Saturation and Intensity (HSI) based color model is most suitable for color segmentation. With manual threshold setting method we have used on both HSI & HSV for all types of rust infected leaves, we found that HSI color model provides the accurate result. This conclusion we have drawn by calculating Ratio of Infected Area (RIA). The formula that is implemented for calculation of RIA provides the good result using manual threshold method. Further detailed study is required for testing the accuracy of the method that is implemented and for automatic detection of soybean rust.

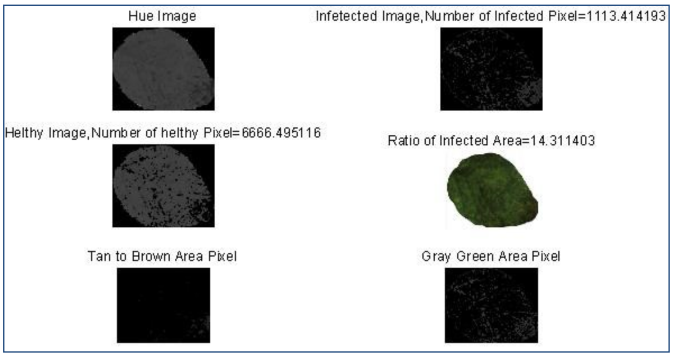

Fig. 2- Hue, Infected and Healthy Image

Conflicts of Interest: None declared.

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