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Color Transform Based Approach for Disease Spot Detection on Plant Leaf

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Abstract— **In this research, an algorithm for disease spot segmentation using image processing techniques in plant leaf is implemented. This is the first and important phase for automatic detection and classification of plant diseases. Disease spots are different in color but not in intensity, in comparison with plant leaf color. So we color transform of RGB image can be used for better segmentation of disease spots. In this paper a comparison of the effect of CIELAB, HSI and YCbCr color space in the process of disease spot detection is done. Median filter is used for image smoothing. Finally threshold can be calculated by applying Otsu method on color component to detect the disease spot. An algorithm which is independent of background noise, plant type and disease spot color was developed and experiments were carried out on different "Monocot" and "Dicot" family plant leaves with both, noise free (white) and noisy background.**

Index Terms— **CIELAB, Color Transform, Plant Leaf Spot Disease, Segmentation and Image Processing**

I. INTRODUCTION

PLANT diseases are important factors, as it can cause significant reduction in both quality and quantity of crops in agriculture production. Therefore, detection and classification of diseases is an important and urgent task. Traditionally farmers identify the diseases by naked eye observation method. In this method disease is visually detected by the experts, who have the ability to detect subtle changes in leaf color. This method is very laborious, time consuming and impractical for large fields. Different experts can detect same part as different disease. To increase accuracy paper grid method is used. Drawback of this method is that this method is laborious. So a fast and accurate approach to identify the plant diseases is needed.

Some researchers have used image processing techniques for fast and accurate detection of plant diseases [1]-[8]. The steps followed by these researchers in detection of leaf spot diseases are: image acquisition, image pre-processing, disease spot segmentation, feature extraction and disease classification. The accuracy of result depends on method used for disease spot detection. The main obstacle in disease spot detection is noise, which is introduced by camera flash, change in illumination, noisy background and presence of vein in the plant leaf. Therefore a method which wipes out the noise and provides better disease spot segmentation is needed.

Nunik Noviana Kurniawati et al [3] introduced a method for detection and classification of paddy disease. In this method Otsu threshold is used for disease spot detection and unnecessary spots are removed using median filter. Geng Ying et al [5] studied the method of image pre-processing for detecting the disease spot. In this paper median filter is used for image smoothing. Threshold technique is used to convert filtered image into binary image and finally using edge detection technique, disease spot is detected. Using above techniques disease spot can be detected in "Monocot family" plants, in which mostly veins are parallel and less visible [9] [10]. Problem occurs when the same technique is applied on "Dicot family" plants to detect the disease spot, in which veins form a netted pattern. In dicot plant leaves, larger veins are thicker and straighter [9], [10]. In the process of disease spot detection disturbance mainly occurs because of these thicker veins.

Monocot Family Plant Leaf [9] Dicot Family Plant Leaf [10]

Fig.1: Difference between Monocot and Dicot family plant Leaf

Veins color is same as plant leaf color only intensity differs. On the other hand, disease spot color is different from plant leaf color. So first if image is transformed from device dependent color space to device independent color space and threshold is applied on color component, one can get better detection of disease spot. Some researchers first convert RGB image into Hue Saturation Intensity (HSI) model and then apply threshold on H component for segmenting infected areas from plant leaves [1], [2]. Di Cui et al developed a fast manual threshold-setting method based on HSI color model to segment the disease spot [6]. Song Kai et al [4] convert RGB image into YCbCr color space to detect the disease spot.

In this paper the effect of YCbCr, HSI and CIELAB color space in the process of disease spot detection are compared. Experiments were carried upon different “Monocot” and “Dicot” family plant leaves with both noise free (white) and noisy background to get the method which is independent of background noise and plant type.

This paper is organized in four sections. Methodology used is described in section 2 that includes 3 steps as follows, Image color transform, image smoothing and disease spot segmentation. Experimentation and results are presented in section 3. Conclusion to the paper is given in last section.

II. METHODOLOGY

Fig. 2 shows the flowchart of the steps involved in the disease spot detection. All the images in collection are in JPEG format. These images are color transformed from RGB image to one of the color space named by YCbCr, HIS and CIELAB color spaces. The color transformed images are passed through median filter to remove unnecessary spots. In last step Otsu threshold is applied on RGB image, ‘A’ component of CIELAB color space, ‘H’ component of HSI color space and ‘Cr’ component of YCbCr color space is used to detect the disease spot. The disease spot segmented images, obtained by all the three methods are compared to get the best method for disease spot detection.

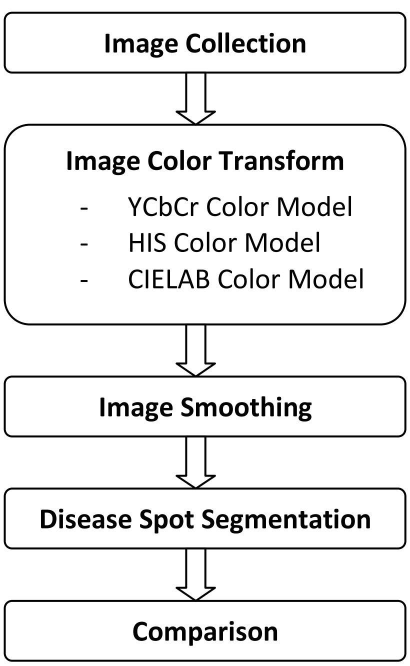

Fig. 2: Flow Chart for Disease Spot Detection using Image Processing

A. *Image Color Transform*

In plants, leaf vein is different in intensity and disease spot is different in color, in comparison to plant leaf. So if Otsu threshold is applied on grayscale image, vein will also be present in binary image with the disease spot. But the region of interest is only disease spots, not vein. For minimize the effect of presence of vein, RGB image should be color transformed before segmentation. After then Otsu threshold can be applied on color component to detect disease spot accurately. In this paper 3 color models are compared.

YCBCR Color Model

This color model is widely used in digital video. In YCbCr color model, ‘Y’ indicates luminance component and Cb, Cr indicates color component. Cb is the difference between the blue components and CR is the difference between the red components [4] [13].

Using following formulas RGB image is transformed into YCBCR color model [11].

$$Y = 0.299 * R + 0.587 * G + 0.114 * B \quad (1)$$

$$CB = -0.168 * R - 0.331 * G + 0.500 * B \quad (2)$$

$$CR = 0.500 * R - 0.418 * G - 0.081 * B \quad (3)$$

HSI (Hue Saturation Intensity) COLOR MODEL

HSI is device dependent color model and based upon Human Color Perception. In this color model ‘H’ indicates Hue, which describes a pure color and is generally related to the wavelength of light. ‘S’ indicates Saturation, which measures the “colorfulness” in HSI color Model. ‘I’ indicates Intensity, which shows the amplitude of the light [7][11][12].

$$H = \begin{cases} \theta \; if \; B \le G \\ 360 - \theta \; \; if \; B > G \end{cases} \quad (4)$$

With

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

$$Saturation(S) = 1 - \frac{3*min(R,G,B)}{(R+G+B)} \quad (5)$$

$$Intensity(I) = \frac{1}{3}(R+G+B) \quad (6)$$

CIELAB Color Model

CIELAB system is device independent which is defined by the CIE to classify color according to the human vision. In the conversion process of an image from RGB color component to CIELAB color component, first RGB image is converted into CIEXYZ using following Equation [3].

$$x = 0.4124 * R + 0.3576 * G + 0.1805 * B \quad (7)$$

$$Y = 0.2126 * R + 0.7152 * G + 0.722 * B \quad (8)$$

$$Z = 0.0193 * R + 0.1192 * G + 0.9505 * B \quad (9)$$

Brightness and color information of LAB color model is independent of each other. In CIELAB color model, ‘L’ describes color brightness; ‘A’ describes the color ranging from green to red; ‘B’ describes the color ranging from blue to yellow. Conversion Formula for LAB color model is [8].

$$L = 0.2126 * R + 0.7152 * G + 0.0722 * B \quad (10)$$

$$A = 1.4749 * (0.2213 * R - 0.3390 * G + 0.1177B) + 128 \quad (11)$$

$$B = 0.6245 * (0.1949 * R + 0.6057 * G - 0.8006 * B) + 128 \quad (12)$$

B. *Image Smoothing*

During image collection, some noise may be introduced because of camera flash. This noise can affect the detection of disease. To remove unnecessary spot, Image smoothing technique is needed. In this paper median filter is used for this purpose.

Median Filter

Median filter is a kind of higher order statistics filter. Median filter is nonlinear in nature, which replaces the value of the center pixel, by the median of the gray levels in the image area enclosed by the filter. The median of a numerical collection is such that half the values in collection are less than or equal to median, and half are greater than or equal to median.

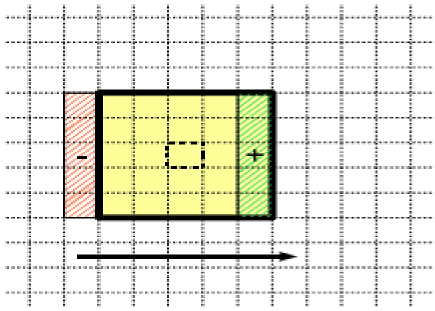

Fig. 3: Process of median filter

In order to perform median filtering, first window is moved and all the pixels enclosed by the window are shorted. After then median is computed and this value is assigned to center pixel. If the number of elements in K*K window is odd, middle value is assigned as median value, else average of two middle values is assigned as median value [5], [11].

C. Disease Spot Segmentation

After image smoothing, a technique to detect the disease spot is needed. It is important to select a threshold of gray level for extract the disease spot from plant leaf. If the histogram has sharp and deep valley between two peaks, bottom of the valley can be chosen as threshold. But problem occurs when valley is flat and broad. In that case this technique can't be used to separate objects from background. Therefore, Otsu method is used in this paper to automatically select most desirable threshold [14].

OTSU Method

In OTSU method, the pixels are separated into two classes C_0 and C_1 (background and object), using a threshold at level K. After then class means (μ_0, μ_1) and class variances (σ_0, σ_1) are calculated. Then a threshold K is searched, that maximizes one of the object functions (l, k, n) [14].

$$l = \frac{\sigma_B^2}{\sigma_W^2}\,; \qquad k = \frac{\sigma_T^2}{\sigma_W^2}\,; \qquad n = \frac{\sigma_B^2}{\sigma_T^2} \qquad (13)$$

III. EXPERIMENTATION

In this research, images of rice, corn, wheat, iris, cotton, soybean, mustard, magnolia, apple and cherry leaf are collected to find the best method for disease spot detection, which is not affected by background and type of plant leaf.

Four methods are discussed in this paper.

- *Method 1:* disease spots are segmented by applying Otsu threshold on RGB image.
- *Method 2:* in second method RGB image is first converted into YCbCr color space using color transform formula. Then median filter is used for image smoothing. Disease spots are detected by applying Otsu threshold on 'Cr' component of filtered YCbCr color space.
- *Method 3:* this is similar to method 2. Only difference is that in place of YCbCr color space RGB image is transformed into HSI color space and disease spots are detected by applying Otsu threshold on 'H' component of filtered HSI color space.
- *Method 4:* again same process is repeated using CIELAB color space. Disease spots are segmented by applying Otsu threshold on 'A' component of filtered LAB color space.

As discussed in previous noise is introduced because of camera flash, noisy background and veins in plant leaf. In order to find the best method among these four methods, research is categorized into three parts.

A. Experiments with Noisy Background

In this part "monocot family plants" are included like rice, corn, wheat and iris with different background and without background. In these plants disturbance is not introduced because of vein. So disturbance is only introduced because of background and camera flash. Only brown spot diseases are included in this section.

Experimental results for disease spot detection of iris leaf affected by heterosporium leaf spot disease using different methods.

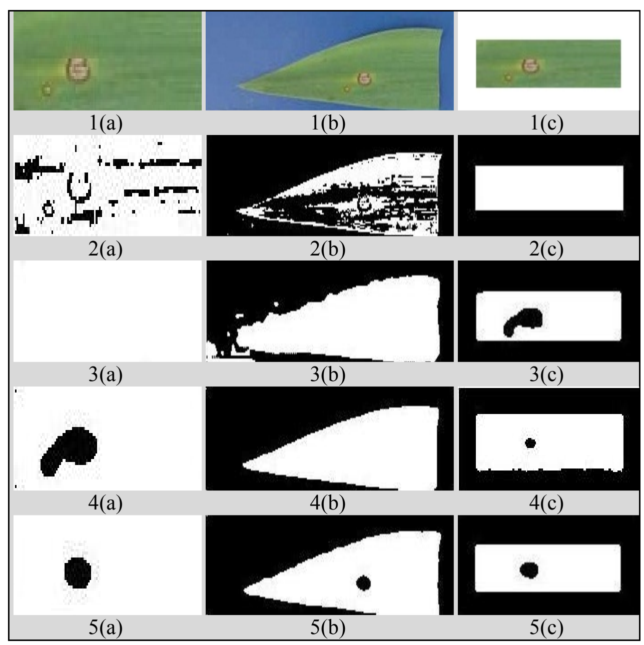

Fig. 4: RGB image of iris leaf affected by heterosporium leaf spot disease, without background(1(a)), with noisy background(1(b)), with noise free background(1(c)) and their respective results of disease spot detection using Method 1(2(a,b,c)), Method 2 (3(a,b,c)), Method 3 (4(a,b,c)) and Method 4 (5(a,b,c)

Experimental results for disease spot detection of rice leaf affected by brown spot disease using different color transform methods.

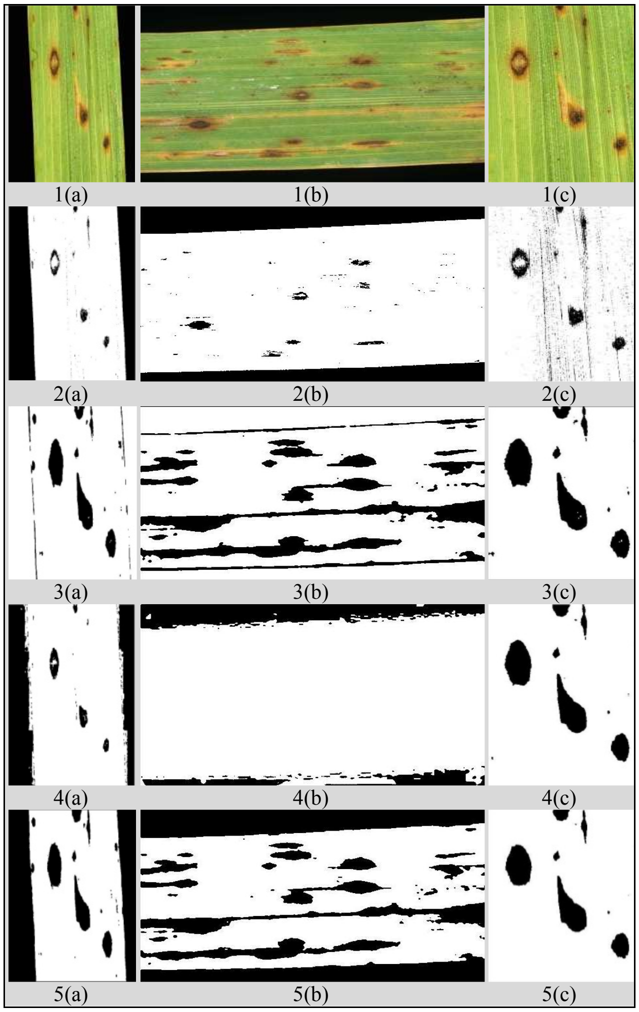

Fig.5 RGB image of brown spot disease on rice leaf, with noisy background(1(a,b)), without background(1(c) and their respective results of disease spot detection using Method 1(2(a,b,c)), Method 2 (3(a,b,c)), Method 3 (4(a,b,c)) and Method 4 (5(a,b,c)

Through these results we can conclude that:

- Using threshold on RGB image disease spot can't be detected accurately (method 1).
- Using threshold on 'H' component of HSI color model and 'Cr' component of YCBCR color model, disease spots can be detected in some cases but not in all. So results are dependent on type of background (method 2, 3).
- Results show that using threshold on 'A' component of CIELAB color model in all cases disease spots are detected accurately and results are independent of background (method 4) (Fig. 4,5 : 5(a,b,c)).

B. Experiment with Disturbance of Vein

In this part "dicot family plants" are included like cotton, soybean, mustard, magnolia, apple and cherry. In these plants noise is introduced because of longer and thicker veins.

Experimental results for disease spot detection of Blueberry leaf affected by bacterial canker (1(a)), frogeye leaf spot lesions on soybean leaf (1(b)), Bacterial blight leaf lesion on cotton leaf (1(c)) using different color transform methods.

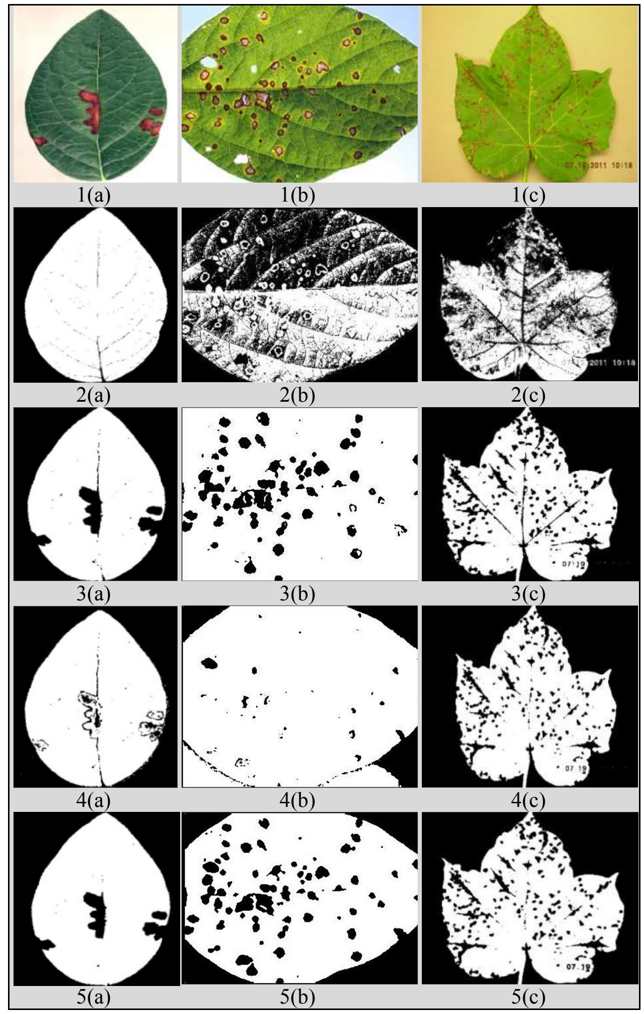

Fig. 6 RGB image of Blueberry leaf affected by bacterial canker (1(a)), frogeye leaf spot lesions on soybean leaf (1(b)), Bacterial blight leaf lesion on cotton leaf (1(c)) and their respective results of disease spot detection using Method 1(2(a,b,c)), Method 2 (3(a,b,c)), Method 3 (4(a,b,c)) and Method 4 (5(a,b,c)

Through these results we can conclude that:

- Using threshold on RGB image neither disease spot is not detected nor disturbance because of vein is eliminated (method 1) (Fig. 6: 2(a, b, c)).
- Using threshold on 'Cr' component of YCbCr color model, some disease spots are detected effectively, but disturbance because of vein is present in results. So results depend on type of leaf and vein (method2) (Fig. 6: 3(a, b, c)).
- Using threshold on 'H' component of HSI color model only few disease spots can be detected. Disturbance because of vein is also present in some cases. So results depend on type of leaf and background (method 3) (Fig. 6: 4 (a, b, c)).
- Using threshold on 'A' component of CIELAB color model disease spots can be detected accurately in all

cases. Experiments show that results are independent of type of plant leaf (method 4) (Fig. 6: 5(a, b, c)).

C. Experiment with Different Colored Disease Spots

Till now it can be concluded that using CIELAB color transform (Method 4) noise is removed effectively, which is generated because of background, camera flash and veins. This method is also checked with different colored disease spots and results are shown in Fig. 7.

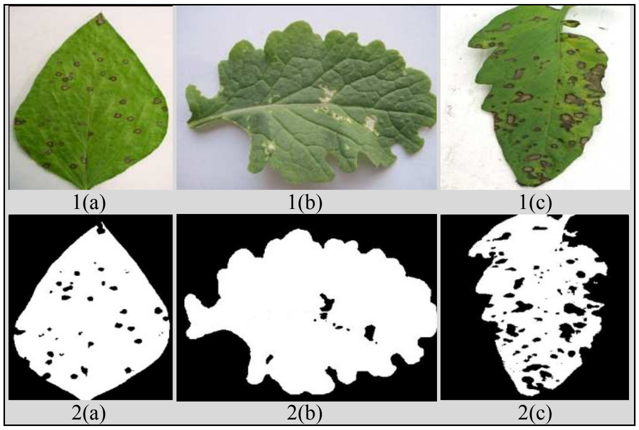

Fig. 7 : RGB image of frogeye leaf spot lesions on soybean leaf (1(a)),white spot on mustard leaf (1(b)), grey spot on tomato leaf(1(c)) and their respective results of disease spot detection using Method 4 (2(a,b,c))

Result shows that different colored disease spots like black, brown, gray and white colored disease spots can be detected accurately using method 4.

In some cases because of micronutrient deficiency and imbalance pigment formation, vein is differ in color in comparison to plant leaf. In these cases disease spots can't be detected accurately using this method.

IV. CONCLUSION

In this paper YCbCr, HSI and CIELAB color models are studied. All these color models are compared and finally 'A' component of CIELAB color model is used. Color transformed image is passed through median filter. In last, disease spots are segmented by applying OTSU threshold on 'A' component of LAB color space.

Experimental result shows that noise which is introduced because of background, vein and camera flash; can be wiped out using CIELAB color model (Method 4). Following this method different disease spots are detected accurately and results are not affected by background, type of leaf, type of disease spot and camera.

Further to this it is needed to compute disease spot area for assessment of loss in agriculture crop. Disease can be classified by calculating dimensions of disease spot. In this work veins having color similar to the spot is not considered. Further work need to be carried out in those lines also.

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