RGB Color Channel Variation Based Segmentation of Crop Leaf Lesion

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***Abstract*—Accurate segmentation of crop leaf lesion is the precondition of precise spraying. A method of lesion segmentation is proposed for image recognition of the precise spraying system in this paper. The method is operated in RGB color space, to separate the normal area and the lesion by intensity change of three color components. The experimental results show that the proposed method achieves a high level of accuracy and real-time performance in terms of the segmentation of brownish red lesion and yellow lesion. Therefore, this method can obtain fairly accurate leaf lesion image.**

Keywords—image segmentation; color channel; crop leaf lesion

I. INTRODUCTION

During the process of crops growth, disease is one of the natural disasters that threaten this process [1]. The use of pesticides in farmland is necessary to prevent and control diseases and ensure the quality of crops. At present, extensive form with a large number of pesticides is the main way to spray in China [2], and there are such application issues as high concentration of pesticide and excessive frequency of spray. On the one hand, this mode of spray causes serious pollution on the environment and produces phytotoxicity that makes the crops physiologically abnormal or even dead. On the other hand, the use of pesticides takes a large part of the cost of crops planting [3] and this mode of spraying leads to high cost and low economic benefit.

Precise spraying system can be operated according to the distribution and level of diseases at a fixed point and in a fixed quantity [4], which means it only sprays crops with diseases, while those crops without diseases won't be sprayed. What's more, this system can decide the volume of spray based on the level of diseases. Accurate and fast segmentation of crop leaf lesion is the primary task to achieve precise spraying and has a direct influence on the judgment of diseases level as well as the volume of spray even further.

At present, there are a large number of methods to segment images of crop leaf lesion both at home and abroad, and these methods are increasingly improved. At the present stage, image segmentation algorithm mainly falls into two parts: classical method and the method combined with specific theories, among which the classical method includes threshold segmentation, edge detection and area segmentation [5]. The method combined with specific theories mainly contains four approaches of segmentation based on statistics, fuzzy theory, mathematical morphology and artificial neural network [6]. The algorithm of classical method is simple and its operant is small, but this method has many limits as well as low accuracy. The method combined with specific theories performs well in its accuracy and application range, but its volume of work is quite large and processing speed is slow. Therefore, this method cannot meet the real-time need.

In terms of using the information of RGB color channel to segment image, there are also some researches applied in different areas both at home and abroad. Thou-Ho Chen [7], T.Celik [8] and some other people employ RGB color model to extract flame pixels and conclude color features of flame pixels through analysis of flame color, and then segment flame in the images. Juan Ignacio Arribas and some other people segment plants from soil through RGB color space [9]. Dian-Yuan Han and some other people find threshold segmentation area of leaves by using the similarity of RGB color space and self adaptive method based on color image. Then, they count the pixel numbers of leaves and rectangle and calculate the area of leaves [10]. In order to test glaucoma measurement optic cup-to-disc ratio, NM Noor and some other people use RGB information to determine threshold value so as to segment the optic cup and optic disc [11].

A new approach was proposed in this paper to quickly segment lesion for precise spraying system. This approach is based on color images of leaves and uses variation of RGB color channel between leaves and lesion area to segment lesion. In the segmentation process, there is no need to gray images. It will maintain information of the original image as far as possible and use RGB color information to directly segment lesion area in order to ensure the segmentation accuracy. Firstly, we analyze the intensity features of R, G and B channels in color image through the observation of tobacco leaves with brown spot disease and analyze their change rules in lesion area. Then, through the analysis of change rules, we find interrelationship between these three color channels and conclude methods to segment lesion by using the difference of RGB color channels. Finally, experiment with tobacco leaves with brown spot disease. Discuss the accuracy, calculation speed and other issues of this method. Compare it with threshold value method and k-means clustering algorithm [12]

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and then you can find that this method enjoys obvious advantages in segmentation accuracy and segmentation speed.

II. Analysis of Color Channel

In digital image processing, RGB color model is the most common hardware-oriented model, which is widely used in color video camera. In practical application, the images directly obtained from the camera are RGB images. Therefore the original images used in this paper are the RGB color images, which allow people to intuitively observe the images color. A RGB image is composed of three color channels: red, green, and blue (R, G, and B), among which each component is an image of 8 bits(256 quantization levels) and the range of R、G and B is [0 255] respectively. Each color pixel of a RGB image is composed of its spatial location in rectangular grid (x, y) and a color vector (R(x, y), G(x, y), B(x, y)). For instance, black is represented by (R, G, B) = (0, 0, 0) and white is represented by (R, G, B) = (255, 255, 255) [13].

A. Features of RGB Color Component of Leaves

Observation of tobacco leaves in Fig.1 clearly shows that the lesion is brownish red in color. Draw the curve of RGB value of the pixels that the white line shows in Fig.1 and we get Fig.2. In Fig.2, it's obvious that in the normal area of leaves, the value of Green channel is the largest and its value is greater than that of Red channel and Blue channel, but the 400-500 range curve changes. Enlarge the change part of curves in Fig.3, we can find that in the lesion area, the value of Red channel is greater than that of the Green channel, and the value of Green channel is greater than that of the Blue channel. Therefore, it is likely to conclude two simple rules for distinguishing lesion pixels from an image, as described in the following:

$$\begin{aligned} R(x, y) - G(x, y) &> 0 \\ G(x, y) - B(x, y) &> 0 \end{aligned} \tag{1}$$

where (x, y) is the spatial location of the pixel. The result of leaves lesion segmentation by this rule is shown in Fig.4.

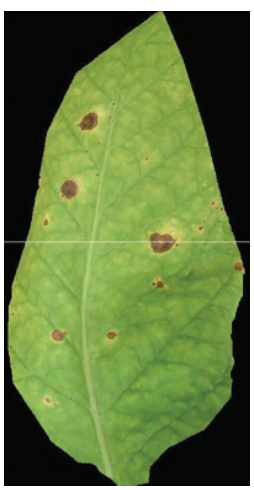

Fig. 1. Tobacco leaf with brown spot disease

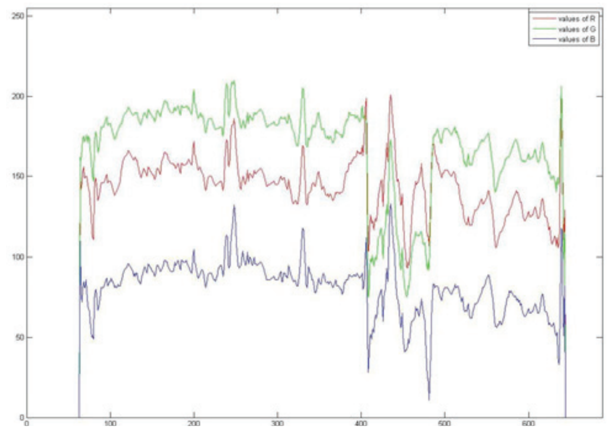

Fig. 2. The RGB value curve of the pixel of one Line in the original image

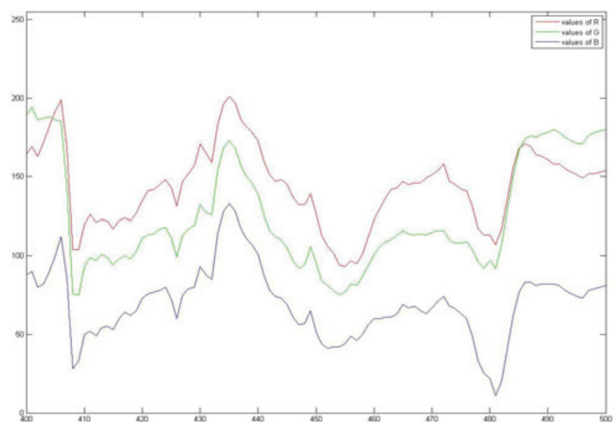

Fig. 3. Curve of enlarged part of 400-500 range

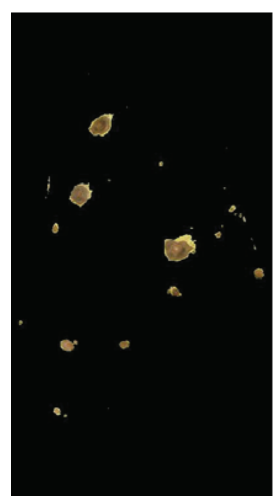

Fig. 4. The result segmented by rule (1)

Then calculate mean values of R, G, and B channels of the whole leaf and the lesion area segmented by rule (1) respectively. The results are given in Table I. By comparing the data in different rows, we find that the mean value of Red channel of lesion is greater than that of whole leaf, while the mean value of Green channel of lesion is less than that of whole leaf, and the mean value of Blue channel does not have remarkable changes. So another rule can be proposed that if the value of Red channel is greater than that of the whole leaf and the value of Green channel is less than that of lesion area, we can find the lesion pixel. The rule can be described as following:

$$\begin{aligned} R\,(x, y) &> R_{m\text{-}leaf} \\ G\,(x, y) &< G_{m\text{-}lesion} \end{aligned} \tag{2}$$

where $R_{m\text{-}leaf}$ is mean value of Red channel of whole leaf, and $G_{m\text{-}lesion}$ is mean value of Green channel of lesion area segmented by rule (1).

By comparing the data in different ranks in Table I, we can find that for whole leaf, the mean value of Green channel is the greatest one of three components, while in lesion area, the mean value of Red channel is greater than that of Green channel and the mean value of Green channel is larger than that of Blue channel. It also proves the rule (1) proposed above. However, after segmentation, some edge pixels of leaves and the yellow part of the lesion are segmented. Therefore, some further segmentation is needed.

TABLE I. MEAN VALUES OF RGB CHANNELS OF THE WHOLE LEAF AND LESION AREA

Area	mean of R	mean of G	mean of B
the whole leaf	134	167	76
lesion	151	130	73

B. *Segmentation Based on RGB Color Channel Variation*

Lesion area can be segmented in general by rule (1), but the effect is not very satisfactory. The existence of over-segmentation, it will affect the follow-up work and get the wrong grade of disease, thereby affecting the amount of spraying.

As can be seen from Fig.3, the variation of red and green component values of the lesion area remained the same trend. The difference is shown in the diagram in Fig.5, we can find that the difference of red and green component of the lesion area is in a certain range. Get the difference of red and green component values of the whole image, make a three-dimensional histogram and a plan view, which can be shown in Fig.6. We can see the difference intuitively from it, so we can get another rule to segment the lesion area for further:

$$R(x, y)\text{-}G(x, y)>T \tag{3}$$

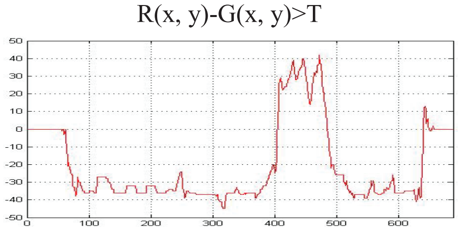

Fig. 5. The difference curve of Red channel and Green channel

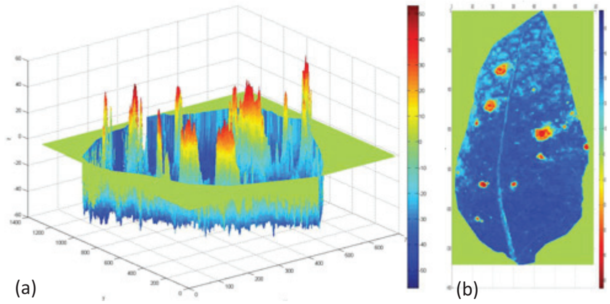

Fig. 6. Three-dimensional histogram of Red channel and Green channel (a) and the plan view (b)

However, selecting a suitable threshold T is a challenging task. If small threshold values are selected there are chances of retaining uninfected areas of small size and if large threshold values are selected there are much lesion areas can be missing [14].

Try to use the difference of red and green component values of the lesion area in Table I as the threshold T, that is $T=R_{m\text{-}lesion}\text{-}G_{m\text{-}lesion}$, while $R_{m\text{-}lesion}$ and $G_{m\text{-}lesion}$ are the mean values of red and green values of lesion area segmented by rule (1) respectively. The increased threshold value will cause the under-segmentation, so get union operation with the result segmented by rule (2), the result is shown in Fig.7.

Next, to remove noises from the images, morphological closing was applied to the binary images [15]. In morphological closing, a dilation operation is carried out after an erosion operation has been performed on the image. It has the effect of smoothing the contour of objects by breaking narrow isthmuses and eliminating thin protrusions from an image. The process and the result of segmentation are shown in Fig.8.

Table II shows the pixel number and the mean value of Red, Green and Blue channels only segmented by threshold T and by the union operation of that and rule (2) respectively. Compare with the result segmented by men used the software named Photoshop, the segmentation rate is 94.37%.

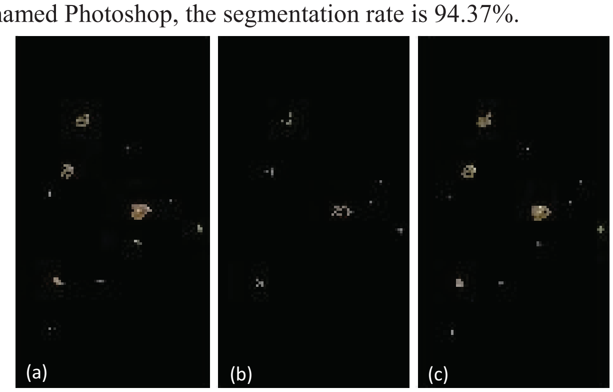

Fig. 7. Comparison of segmentation method: (a) segmented by T, (b) segmented by rule (2), (c) union operation of (a) and (b)

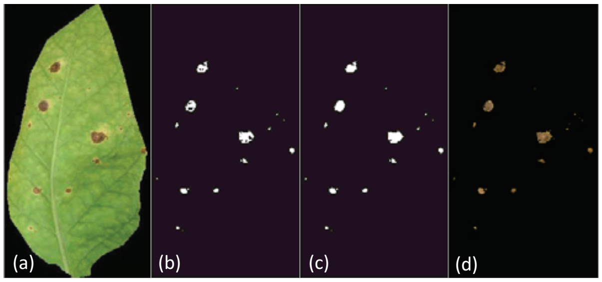

Fig. 8. Process and result of segmentation: (a) the original image, (b) segmented by union operation, (c) morphological closing and hole filling, (d) final segmentation result

TABLE II. RESULT OF SEGMENTATION METHOD

	pixel number	**mean of R**	**mean of G**	**mean of B**	**over/under rate**
T	8301	136	108	63	11.24%
union	8910	136	109	62	5.64%
men	9352	136	110	62	/

III. PERFORMANCE ANALYSIS

In order to verify the performance of the lesion segmentation method based on RGB color channel variation, the contrast experiments with other algorithms are necessary. We choose threshold value method and k-means clustering algorithm as comparison, the result is showed in Table III and Fig.9. Using of threshold value method require the transform from color images to gray images, then segmented the images by threshold value, so as a result of factors such as brightness, lesion pixels and leaf pixels will have a similar intensity in gray images, resulting in far from ideal segmentation results. Using k-means clustering algorithm, the lesion area may wrong segmented or over segmented, and with relatively long time. This method also performs relatively poor in timeliness. The proposed method in this paper, in terms of segmentation performance and timeliness has a distinct advantage.

TABLE III. COMPARISON OF SEGMENTATION METHOD

	pixel number	**mean of R, G, B**	**over/under rate**	**time**
threshold value	28756	96, 123, 43	207.48%	5.17s
k-means	10887	143, 118, 68	16.41%	64.59s
this paper	8910	136, 109, 62	5.64%	12.31s
men	9352	136, 110, 62	/	/

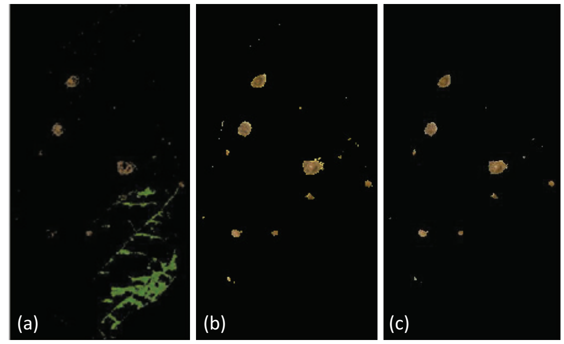

Fig. 9. Comparison of segmentation result: (a) threshold value, (b) k-means, (c) this paper

IV. CONCLUSION

This paper proposed an approach of lesion segmentation based on the variation of color channel in RGB color space, it can use RGB color information directly. There is no need to transform the images, and it will maintain information of the original image as far as possible. When the approach is applied to segmentation of brown spot lesion, segmentation rate reached 94.73%, and the effectiveness and timeliness can be seen through comparative experiments with threshold value method and k-means clustering algorithm.

The lesion segmentation approach can be used for image recognition part of precise spraying system, which to determine the disease level of crop leaf based on the segmented lesion, in order to determine the amount of spraying. Currently, the approach has certain limitations, it can only segment brownish red and yellow lesions, white spots invalid. And the change of brightness will affect the color channel, deduce the accuracy of the approach to some extent. In future works, we need to be able to apply a segmentation method which can adapt to different colors of lesion, and try to apply in other color spaces to ensure the segmentation method is more robust.

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