

Image Segmentation Method for Brassica Napus L. Based on PSO and Color Space Model



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Abstract. Image processing technology is used to identify the lesions and wormholes of the leaves, and then the pests and diseases of the crops can be analyzed. The segmentation of the leaf images from the background image accurately is a key part of the recognition process. Therefore, a image segmentation method is proposed for Brassica napus L. based on PSO algorithm and color space model. Firstly the color component image of the highlighted target area is obtained using the color space model. Then its optimal segmentation threshold is calculated using the PSO algorithm based on the inter-class variance method. Finally, the image is split using the threshold segmentation method. The segmentation results of multiple leaf images show that the proposed method can improve the segmentation accuracy of the image of Brassica napus L., and the error rate is less than 10% and the average error rate of 20 images is 0.91242%. Therefore the proposed method satisfies the accuracy requirements of agricultural applications and has a better segmentation effect than the Otsu algorithm.

Keywords: Brassica napus L, color space model, image segmentation, PSO algorithm

1 Introduction

Brassica napus is one of the main raw materials for grain and oil in China, so ensuring the yield of Brassica napus is extremely important for daily life. In recent years, digital image processing technology has been more and more used to research on crops [1-4], including research on rape. Zhao [5] detected the pests and diseases of rapeseed based on hyperspectral and image processing, Kang et al. [6] researched the quality of rapeseed based on near-infrared image. In the various research processes of rapeseed, it is a key step in image analysis to identify the leaf image from the background image.

Since the middle and late 20th century, there have been more and more researches on image segmentation, and there are many methods proposed. Major image segmentation methods can be summarized into four types: threshold segmentation method, edge detection method, region extraction method and method based on some theory. Among them, the threshold segmentation method is used commonly because of its simple theory and wide application range. The key point of the threshold segmentation method is to select the appropriate threshold. At present, there are many methods for selecting the threshold. Otsu algorithm is used widely, which derives the optimal segmentation threshold using the least squares method. It is found that only Otsu algorithm will get the poor segmentation effect in actual, so many scholars combined the Otsu algorithm with other theories to improve the segmentation accuracy. Wang et al. [7] proposed an retinal vessel auto-segmentation algorithm based on improved high and low cap transform method and Otsu algorithm. Firstly the image was enhanced using the high and

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low cap transform, and then was modified to reduce the influence of pathological state on the blood vessels. Finally the vessel image was split using the Otsu algorithm. Yuan et al. [8] designed an unsupervised image synthesis method of color image for the yellow leaf disease image with complex background. Firstly the disease part of the image was extracted using the super-G and Otsu algorithm. Then a graph cutting method based on threshold segmentation method was used to achieve automated segmentation of leaf lesions.

Considering that only the background and the blade with noise are included in the research object, the inter-class variance method can be selected. But because this method only uses the grayscale information, ignoring the spatial information and color information, the segmentation effect is poor. According to the research ideas of predecessors, this paper proposes an improved threshold segmentation method using PSO algorithm and color space model. Firstly, the target that can highlight the blade target is found using the difference of the color information between the background and the blade in image based on the color space model. The optimal segmentation threshold of the color component is then obtained using the inter-class variance method improved by the PSO algorithm. Finally, the image is segmented by the threshold segmentation method.

2 Algorithm Introduction

2.1 Inter-Class Variance Method

The inter-class variance method uses the gray histogram of the image to calculate the optimal threshold. With this threshold, the image can be divided into two parts: the background and the target, so that the variance between the two parts is the largest and the intra-class variance is the smallest.

Let $f(x, y)$ be a grayscale image with a gray level of L . Assuming an initial segmentation threshold is t , the pixels in the image $f(x, y)$ can be divided into two groups: c_1 and c_2 . There are w_1 pixels in the c_1 group and the gray scale range of each pixel is $0 \sim t-1$, then the gray average value of the group is m_1 ; the c_2 group has w_2 pixels, and the gray range of each pixel is $t \sim L-1$, so the gray average value of the group is m_2 . Using the formula (1), the intra-group variances σ_1^2 and σ_2^2 can be calculated separately:

$$\sigma^2 = \sum [f(x, y) - m]^2 \quad (1)$$

Where, m is the gray average value of the group, σ^2 is the intra-group variances.

So the intra-group variances of the total pixels of the image is calculated:

$$\sigma_w^2 = \sigma_1^2 + \sigma_2^2 \quad (2)$$

The variance between the two parts is calculated by formula (3):

$$\sigma_B^2 = w_1(m - m_1)^2 + w_2(m - m_2)^2 \quad (3)$$

The inter-class variance method uses σ_B^2 / σ_w^2 to evaluate the segmentation effect. When the calculated σ_B^2 / σ_w^2 is the largest, the corresponding t is the optimal threshold.

2.2 Image Segmentation Method Based on PSO (Particle Swarm) Algorithm

Particle Swarm Optimization (PSO) is a model of simulated bird population or fish population proposed by Kennedy and Eberhart in 1995 [9]. The particle swarm algorithm abstracts the bird into a "particle" and all particles are in a D-dimensional space. Where each particle has a fitness, determined by the objective function, which can be used to determine the current position. Each particle can remember the best position (pbest) searched by itself and the best position (gbest) found by all particles in the entire population. The speed of each particle is adjusted to determine the next flight distance and direction using pbest and gbest.

In the D-dimensional space, there are m particles, and two optimal values (gbest, pbest) are found according to the fitness values of each particle. The new velocity v_i and position x_i of the particle are calculated:

$$v_i = v_i + c_1 * r_1 \times (p \text{ best}_i - x_i) + c_2 * r_2 \times (g \text{ best}_i - x_i) \tag{4}$$

$$x_i = x_i + v_i \tag{5}$$

Where c_1 and c_2 are learning factors, usually taking the value 2. And r_1 and r_2 are pseudo-random numbers between (0, 1). The maximum value of v_i is v_{\max} (greater than 0), and the range of x_i is $[[x_{\min}, x_{\max}]]$.

Combined with the topic of this paper, the idea of the PSO algorithm is described as follows:

a. Initialization: the position of the particles in the population is a random number between 1 and 256, and the velocity of the particle is any random number greater than 0. The number of individual population is 256, and the maximum number of iterations is 200.

b. Update pbest and gbest: the best fitness value and position pbest of each particle are calculated and record using the objective function σ_B^2 / σ_W^2 , and then the global optimal fitness value and position gbest are found.

c. Iterative and optimization: the position and velocity of the particle are updated according to equations (4) and (5) and then round up the updated position. After the fitness value of the current particle is calculated, the individual optimal fitness value and global optimal fitness value can be updated.

d. Termination condition: Steps b and c are repeated until the maximum number of iterations or the global optimal position is reached. The global optimal adaptation value at this time is the optimal threshold searched by the particle swarm algorithm.

2.3 Color Space Model

Color space model mainly include RGB model, HSV model, HIS model, YIQ model, YUV model and so on. Different color space model is expressed by different primary components. All models can express the same color and different models can be transformed into each other.

Image segmentation based on color space model is to superimpose color components of the target region and to obtain the best image to be segmented using the color component of each model [10]. It has been found through experiments that for the research topic, the color components of the RGB model and the YIQ model can be used to obtain the better result. Only the two color space models are introduced here.

(1) RGB model

The RGB model uses the three primary colors Red (Red), Green (Green), and Blue (Blue) specified by CIE. The model uses RGB color cubes, as shown in Fig. 1. The image of Brassica napus leaves in this model is shown in Fig. 2.

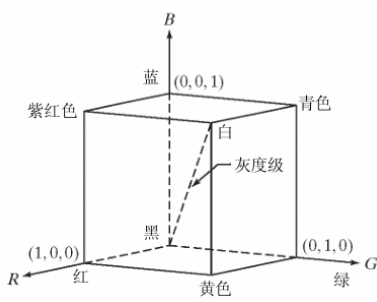


Fig. 1. RGB model



Fig. 2. the original image of Brassica napus leaves

Color component images of the original image can be obtained based on the RGB model. Three component images of the leaf image of *Brassica napus* L are shown in Fig. 3(a), Fig. 3(b), and Fig. 3(c).

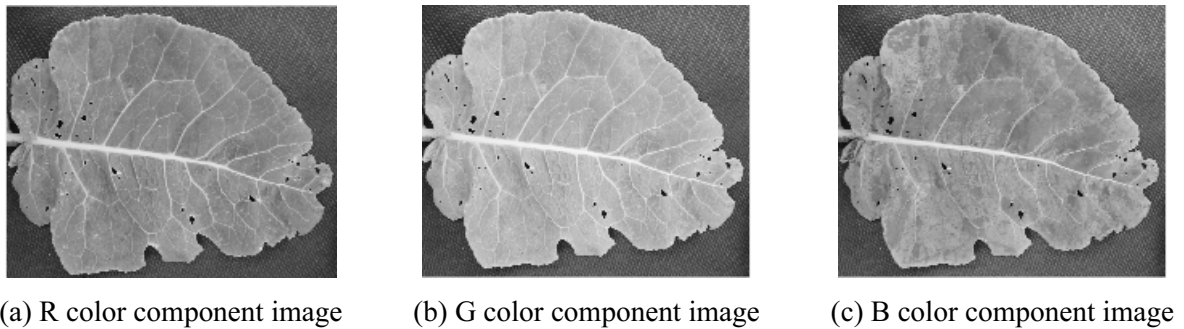


Fig. 3. color component image of RGB model

The whole blade is green in the original image. So in order to identify the target area well, the difference among the green and red and blue components can be utilized. As can be seen from Fig. 3, the color of the blade in the G component image is brighter than the background color. So the R component or the B component can be subtracted from the G component to highlight the target region, as shown in Fig. 4(a) and Fig. 4(b). The color of the blade area in both images is brighter than the background, but the difference is not obvious. In order to highlight the target area, the two component difference images can be superimposed to obtain Fig. 4(c), in which the difference between the target area and the background area is large.

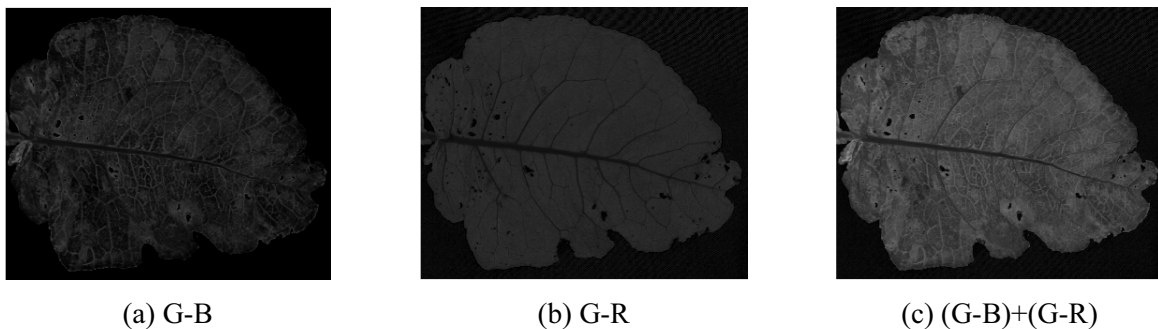


Fig. 4. color difference image

(2) YIQ model

YIQ is a color space specified by the NTSC (National Television Standards Committee) television system, which separates grayscale information from color data. Y stands for Luminance, and I (In-phase) and Q (Quadrature-phase) carry color information, which describes the color and saturation properties of the image. The I component represents the color changes from orange to cyan, and the Q component represents the color changes from purple to yellowish green.

The YIQ component can be obtained from the RGB component using a linear transformation:

$$\begin{cases} Y = 0.299R + 0.587G + 0.114B \\ I = 0.596R - 0.274G - 0.322B \\ Q = 0.221R - 0.523G + 0.312B \end{cases} \quad (6)$$

After the color image is transformed by the formula (6), three components of the YIQ model are obtained, as shown in Fig. 5.

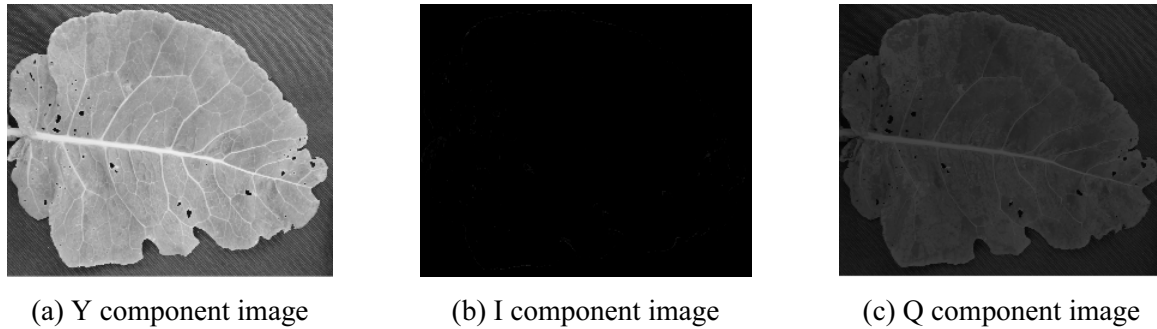


Fig. 5. YIQ component image

It can be seen from Fig. 5(c) that the leaf area and the background area have a large color difference, and the background is darker than the target area color in the Q component image.

In summary, the color component image that can highlight the target area in each color space model is shown in Fig. 6. Fig. 6(a) and Fig. 6(b) are superimposed to obtain Fig. 6(c), in which the grayscale difference between the target area and the background area is more pronounced, and the target area is more complete.

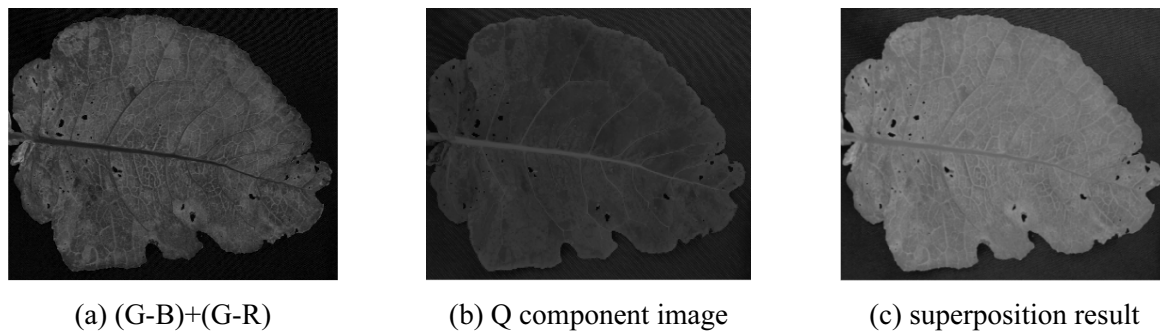


Fig. 6. the component image in which the target area can be highlighted and the superimposed component image

2.4 Segmentation Method Based on PSO and Color Space Model

For the image with simple color and gray histogram showing high and narrow bimodal and the large gray value difference between the target and background, the threshold segmentation method can have better segmentation effect. The image of the blade collected outdoors, which has complex background and will be affected by illumination, etc., will increase the difficulty of image segmentation. At this time, the threshold segmentation method can not obtain a good effect. In this paper, the color information of the blade image is used to improve the situation. The color space model is used to obtain the color component image that can highlight the target region. Then the PSO algorithm is used to obtain the optimal segmentation threshold of the color component image, and finally the image segmentation is realized. Specific steps are as follows:

(1) Using the RGB model and the YIQ model, color component images that can highlight the target area are respectively extracted and then superimposed as grayscale images to be segmented.

(2) Search the optimal segmentation threshold of gray image using standard PSO algorithm:

(3) The R component, G component, and B component image of the original image are separately segmented using the optimal threshold value searched. Then three color component images are reconstructed to obtain the segmentation color image.

3 Experimental Result and Analysis

In the environment of MATLAB2016a, the segmentation method of this paper is programmed and verified by experiment taking Fig. 2. as an example. In order to make the results more obvious, the method of this paper is compared with the artificial method and Otsu algorithm, and the segmentation results are shown in Fig. 7.

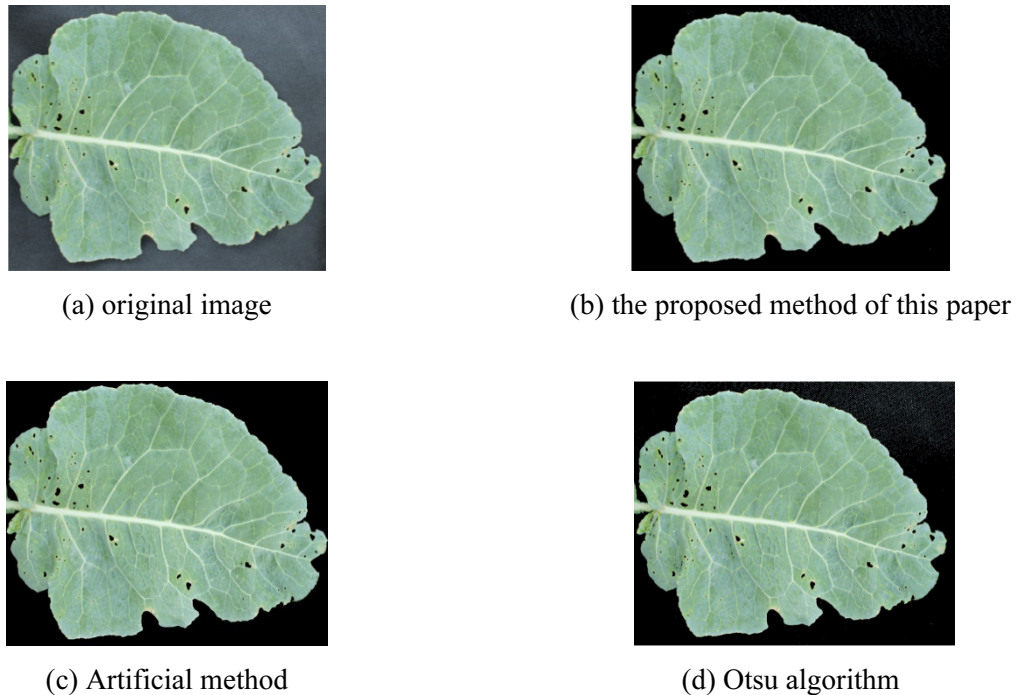


Fig. 7. Segmentation results

It can be seen from the above figure that the segmentation result of the algorithm is similar to the artificial segmentation result. The blade target is completely recognized, and the background contains only a small amount of noise. But the processing result of Otsu algorithm is very poor. The background contains a lot of noise, which seriously affects the segmentation effect.

In order to test the effectiveness of the proposed algorithm, 20 *Brassica napus* L. leaf image can be tested. The number of pixels in the leaf area contained by the proposed method and by artificial segmentation can be calculated respectively, so that the error rate(*rate*) of image segmentation can be calculated:

$$rate = \frac{|s - s_0|}{s} \times 100\% \quad (7)$$

Where s_0 is the number of pixels of the blade area obtained by the proposed method, and s is the number of pixels of the blade area obtained by artificial segmentation. The artificial segmentation here uses Photoshop to extract the blade layer and store it as a new image. Then the image is converted to binary one in matlab, and then the number of pixels in the blade area is counted.

The test results of the 20 blade images are shown in Table 1.

Table 1. Experiment data of image segmentation of Brassica napus L

Image number	The number of pixels by artificial method	The proposed method		Image number	The number of pixels by artificial method	The proposed method	
		The number of pixels	The error rate (%)			The number of pixels	The error rate (%)
1	3281900	3268800	0.4000	11	3807029	3841228	0.9000
2	4052600	4053300	0.0162	12	4030614	4264444	5.8000
3	3624500	3612300	0.3400	13	3281338	3264836	0.3300
4	3476200	3473323	0.0827	14	4389837	4392438	0.0592
5	4111900	4124651	0.3100	15	3642147	3773761	3.6100
6	3684447	3672068	0.3400	16	3553189	3588602	1.0000
7	3765008	3781081	0.4300	17	3722724	3713854	0.2400
8	4022100	4024022	0.0478	18	3649011	3748532	2.7300
9	3904840	3882850	0.0516	19	3430441	3428352	0.0609
10	3623800	3615215	0.2400	20	3159813	3199689	1.2600

It can be seen from Table 1 that the number of pixels in the blade region obtained by the method of this paper is very close to the number of pixels obtained by the manual method. The error rate is less than 10%, and the average error rate of the 20 images is 0.91242%. In short the segmentation accuracy using the proposed method is better.

4 Conclusion

(1) The image of the blade collected outdoors is easily affected by illumination, etc., resulting in a small contrast between the target and the background region in the grayscale image, and the poor segmentation effect. Aiming at this problem, this paper proposed an image segmentation method for Brassica napus L. based on PSO and color space model. Firstly, the color space model is used to find the color component that can highlight the target area, and the component image is selected and superimposed as the gray image to be processed. Then the PSO algorithm is used to find the optimal segmentation threshold, which can be used to split image based on the theory of the inter-class variance method.

(2) Experiments results showed that compared with the Otsu algorithm, the proposed method can segment the blade region from the color image more accurately, and the error rate of segmentation is less than 10%, and the average error rate is 0.91242%, which satisfies the requirement of segmentation accuracy. Further improvement of the segmentation method has the good segmentation effect on the leaf image with the small contrast between leaf vein and background affected by illumination, which is the future research direction.

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