Study on recognition of black insects on dark background by computer vision

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***Abstract*—Improved color channel comparison method (ICCCM) is an effective method to transform color images into gray-scale ones. Based on the ICCCM, black or white insects could be effectively extracted and recognized from the real color images with bright background. However it is difficult to use the ICCCM to extract and recognize the black insects from the real color image with dark background. In this paper, the ICCCM is modified to transform the color images into the gray ones, extracting and recognizing the black insects on the dark background. The ICCCM is modified as follows: (1) A threshold of the gray image is an average brightness value of red (R), green (G) and blue (B) in all the image pixels. (2) The bright pixels and the color pixels have the highest brightness value 255 in the gray image. (3) A pixel brightness value of the dark area in the gray image equals to a minimum of R, G and B in the pixel. (4) After deleted all the pixels with a brightness value of 255, a threshold of the binary image is determined by Otsu's theory. The modified ICCCM more effectively extracts and recognizes the black insects from the real color images with dark background compared with the ICCCM.**

Keywords-black insect; extraction of insect; dark background; color-to-gray transformation; computer vision

I. INTRODUCTION

It is significant for preventing and controlling insect pests in agriculture and forestry. A computer vision can play an important role in the prevention and control of the insect pests. An insect recognition technology based on the computer vision has attracted considerable attention for its potential applications in agricultural engineering [1-5].

Recently, we have proposed a color channel comparison method (CCCM) for recognizing black and white insects and have used to extract and recognize the black and white insects from the real color images [6]. Moreover, we further improved the CCCM and used the improved color channel comparison method (ICCCM) to treat the real color images in which there were the black and white insects [7]. It was found that the ICCCM was more effectively extract and recognize the black and white insects from the real color images compared with the CCCM [7]. However, we also found that the ICCCM could not effectively extract and recognize the black insects from the real color images with dark background. In the present work, the ICCCM is modified to extract and recognize the black insects from the real color images with the dark background. An effect comparison of the modified ICCCM with the ICCCM will be given.

II. RECOGNITION METHODS

A. Improved color channel comparison method (ICCCM)

According to the trichromatic theory, when red (R), green (G) and blue (B) have the same brightness value, they are mixed to obtain a gray image. In the gray image, pure white pixels have highest brightness while pure black ones have lowest brightness. Generally, brightness of the gray image is a middle value between white and black images. On the other hand, many insect pests are white or black. Therefore, according to the trichromatic behavior of the white and black objects, the CCCM was used to extract and recognize the white and black insects [6].

For the black insect pests, if a difference between the highest and lowest values of R, G and B in a pixel is larger than 20, the gray value of the pixel equals to five times of the highest value of R, G and B, otherwise the gray value equals to one fifth of the lowest value of R, G and B. The brightness L of the pixel in the gray image is expressed as [6]

$$\begin{aligned} &L = 5\times \mathrm{Max}(R,G,B) \quad \text{if } \mathrm{Max}(R,G,B) - \mathrm{Min}(R,G,B) > 20 \\ &L = \frac{\mathrm{Min}(R,G,B)}{5} \quad \text{if } \mathrm{Max}(R,G,B) - \mathrm{Min}(R,G,B) < 20 \end{aligned} \tag{1}$$

As it is well known, the brightness recognition of the human eyes ranges from 10 to 20. Furthermore, in the multi-threshold model of the color and gray images, the lowest threshold is about 20 [8]. Thus the threshold in (1) is considered to be 20 [6].

Moreover, the ICCCM was further proposed in order to obtain a good recognition result of the insect [7]. For the black insects, if a difference between the highest and lowest values of R, G and B in a pixel is larger than 20, the gray value of the pixel equals to five times of the highest value of R, G and B. Thus the brightness of the bright area in the image is further enhanced, creating a high contrast between the black insect and the background. On the other hand, if a difference between the highest and lowest values of R, G and B in a pixel is less than 20, some gray background areas can interfere with the extraction and recognition of the black insects. Therefore, an average brightness value of the minimum of R, G and B in each pixel, named aveMin, is introduced as a new threshold to clear the interference of the gray background areas. If a difference between the highest and lowest values of R, G and B in a pixel is less than 20 and a minimal brightness value of R, G and B in the pixel is

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larger than aveMin, the pixel is the interference point which should be deleted. Thus the brightness value of the bright background areas interfering with the black insect is enhanced, creating a contrast between the black insect and the bright background. If a difference between the highest and lowest values of R, G and B in a pixel is less than 20 and a minimal brightness value of R, G and B in the pixel is less than aveMin, the pixel is considered to be the point of the black insect. According to the ICCCM, the brightness L of the pixel in the gray image is given by [7]

$$\begin{aligned} &L = 5\times \mathrm{Max}(R,G,B) \quad \text{if } \mathrm{Max}(R,G,B) - \mathrm{Min}(R,G,B) > 20 \\ &L = 5\times \mathrm{Max}(R,G,B) \quad \text{if } \mathrm{Max}(R,G,B) - \mathrm{Min}(R,G,B) \le 20 \\ &\qquad \& \ \mathrm{Min}(R,G,B) > \mathrm{avgMin} \\ &L = \frac{\mathrm{Min}(R,G,B)}{5} \quad \text{if } \mathrm{Max}(R,G,B) - \mathrm{Min}(R,G,B) \le 20 \\ &\qquad \& \ \mathrm{Min}(R,G,B) \le \mathrm{avgMin} \end{aligned} \tag{2}$$

It was found that the ICCCM could not effectively extract and recognize the black insects from some more complicated images because it only considered the elimination of the bright background points in the image. Therefore, the ICCCM should be further modified.

B. Modified ICCCM

The ICCCM does not eliminate the dark background and only eliminates the bright background points in the real color image. Therefore, for the ICCCM, the formulae of the pixel brightness in the gray image should be modified.

Firstly, the threshold (aveMin) in the ICCCM is revised to equal to an average brightness value of R, G and B in all the image pixels. Thus the threshold T in the modified ICCCM contains more comprehensive information about the real color image.

Secondly, for the black insects, the color pixels become the highest brightness value 255 in the gray image if a difference between the highest and lowest values of R, G and B in a pixel is larger than 20. The bright pixels also become the highest brightness value 255 in the gray image if a difference between the highest and lowest values of R, G and B in a pixel is less than 20 and a minimal brightness value of R, G and B in the pixel is larger than T. It can eliminate the influence of the background on the black insects as effectively as possible.

Thirdly, the brightness value of the pixel in the gray image equals to a minimum of R, G and B in the pixel if a difference between the highest and lowest values of R, G and B in a pixel is less than 20 and a minimal brightness value of R, G and B in the pixel is less than T. Thus the pixels of the insect more darken.

Fourthly, after deleted all the pixels with a brightness value of 255, a threshold to obtain the binary image is obtained by Otsu’s theory. The threshold of the binary image is determined by the black insect and the dark background area because all the pixels with a brightness of 255 are deleted. Therefore the black insect is more effectively extracted and recognized from the real color images with the dark background. The gray image is transformed into the binary image in terms of the threshold.

Finally, according to the content described above, the ICCCM is modified in order to extract and recognize the black insects from the real color images with the dark background. For the modified ICCCM, the brightness L of the pixel in the gray image is express as

$$\begin{aligned} &L = 255 \quad \text{if } \mathrm{Max}(R,G,B) - \mathrm{Min}(R,G,B) > 20 \\ &L = 255 \quad \text{if } \mathrm{Max}(R,G,B) - \mathrm{Min}(R,G,B) \le 20 \\ &\qquad \& \ \mathrm{Min}(R,G,B) > T \\ &L = \mathrm{Min}(R,G,B) \quad \text{if } \mathrm{Max}(R,G,B) - \mathrm{Min}(R,G,B) \le 20 \\ &\qquad \& \ \mathrm{Min}(R,G,B) \le T \end{aligned} \tag{3}$$

III. Results and Discussion

Figure 1 shows a real color image of *Halyomorpha picus Fabricius*. As shown in Fig. 1, the black insect settles on a green leaf and the dark background area mainly is brown areas marked by the arrows. Figure 2 shows a real color image of *Erthesina fullo Thunberg*. As shown in Fig. 2, the black insect settles on a gray wall and the dark background area is the gray wall.

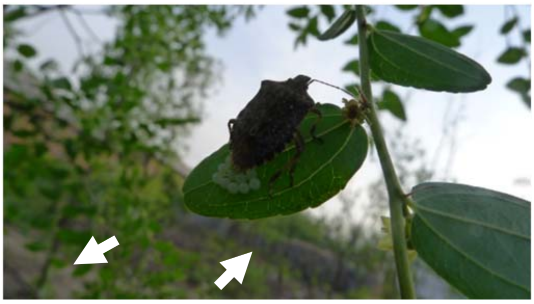

Figure 1. A real color image of *Halyomorpha picus Fabricius*. The arrows represent the brown background areas.

Figure 2. A real color image of *Erthesina fullo Thunberg*.

According to the ICCCM, using (2) and Otsu's theory, the real color images shown in Fig. 1 and Fig. 2 were processed. These two original images were transformed into the binary images. Figure 3 and Figure 4 show the binary images of the

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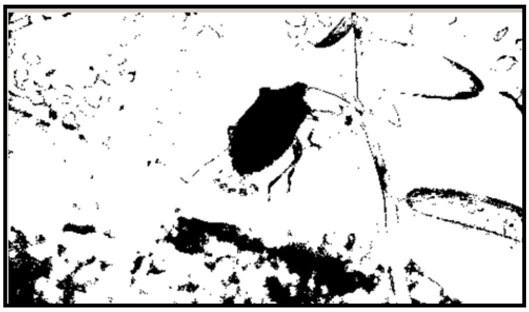

Figure 3. A binary image of Fig. 1, using the ICCCM.

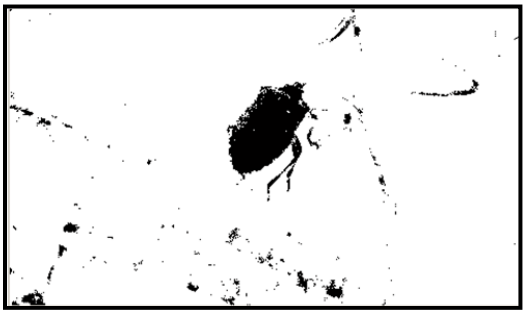

Figure 7. A binary image of Fig. 1, using the modified ICCCM.

Figure 4. A binary image of Fig. 2, using the ICCCM.

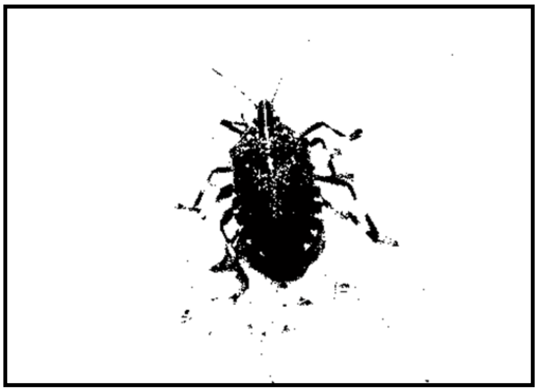

Figure 8. A binary image of Fig. 2, using the modified ICCCM.

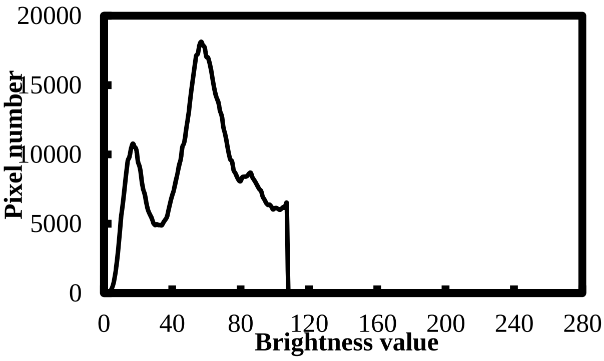

Figure 5. A histogram of Fig. 1, using the modified ICCCM.

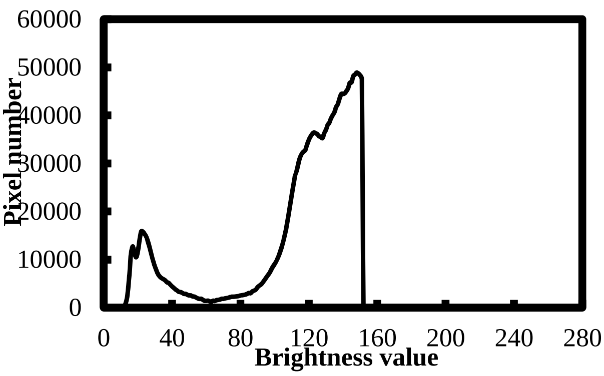

Figure 6. A histogram of Fig. 2, using the modified ICCCM.

Fig. 1 and Fig. 2, respectively. As can be seen from Fig. 3 and Fig. 4, the brown background areas and the gray wall cannot be effectively cleared. Namely, the ICCCM could not effectively eliminate the dark background. The ICCCM does not extract and recognize well the black insects from the real color images, particularly for the image with a large area of the dark background such as Fig. 2.

According to the modified ICCCM, using (3) and Otsu's theory, the real color images shown in Fig. 1 and Fig. 2 were processed. These two original images were transformed into the binary images. It should be noted that for the modified ICCCM the threshold is obtained by Otsu's theory after deleted all the 255 bright pixels. Figure 5 and Figure 6 show the histograms of the gray images of Fig. 1 and Fig. 2. As shown in Fig. 5 and Fig. 6, the thresholds of the binary images are determined by the black insects and the dark background areas because all the pixels with a brightness of 255 are deleted. The threshold of the binary image is 53 for Fig. 1 and that is 80 for Fig. 2. Figure 7 and Figure 8 show the binary images of Fig. 1 and Fig. 2, respectively. As can be seen from Fig. 7 and Fig. 8, the brown background areas and the gray wall are effectively cleared. Namely, the modified ICCCM effectively eliminates the dark background. The modified ICCCM extracts and recognizes well the black insects from the real color images with the dark background. In a word, the modified ICCCM more effectively extracts

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and recognizes the black insects from the real color images with the dark background compared with the ICCCM.

IV. SUMMARY

In order to extract and recognize the black insects from the real color images with the dark background, the ICCCM is modified as follows: (1) The threshold of the gray image is the average brightness value of R, G and B in all the image pixels. (2) The bright pixels and the color pixels have the highest brightness value 255 in the gray image. (3) The pixel brightness value of the dark area in the gray image equals to the minimum of R, G and B in the pixel. (4) After deleted all the pixels with the brightness value of 255, the threshold of the binary image is determined by Otsu's theory. The modified ICCCM more effectively extracts and recognizes the black insects from the real color images with the dark background compared with the ICCCM.

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