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Edge detection algorithm of plant leaf image based on improved Canny

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***Abstract*: Edge detection technology is a key technology in the field of image processing. Aiming at the problem that traditional Canny algorithm has poor adaptive ability and cannot effectively determine image edge, this paper proposes an improved Canny edge detection algorithm. The algorithm uses an improved filtering method to de-noise the image. Secondly, the four-direction gradient template is used to calculate the gradient amplitude. Finally, the high and low thresholds of images are obtained by image block processing combined with the maximum inter-class variance (Otsu) algorithm. The experimental results show that the improved Canny algorithm has good noise reduction performance and can detect the edge information of plant leaves more accurately.**

Key words: Plant leaves ;Canny algorithm;Otsu algorithm ;Edge detection;

I. INTRODUCTION

With the development of society, digital image processing technology has become more and more important, especially in the field of plant classification has been widely used. Image edge detection greatly reduces the amount of data, and removes the irrelevant information. It can retain the important edge information of the image. After edge detection, the color of the image is relatively simple, and only the information we need is retained, leaving out other image information, so that the speed of the computer is very fast in the process of post-processing image[1]. After the edge detection of the image, in the computer pixel is relatively small, the computer's reading and writing speed is very fast. Under the premise of not losing key information, it will greatly reduce the amount of computing for the computer and provide great help to the researchers[2].

Canny operator has good signal-to-noise ratio, accurate edge positioning accuracy, low error rate of edge detection and low mean square error[3].But any kind of original operator can not deal with the image to the perfect effect. In order to get a more ideal edge detection image, we can only improve the algorithm, modify the filtering parameters, determine the gradient direction and modify the threshold setting method according to our needs, so as to accurately locate the edge of the image.

This paper proposed an improved Canny operator edge detection algorithms, this algorithm first use of adaptive filter instead of traditional filter to remove noise, and then using the horizontal, vertical, 45 ° and 135 ° four direction of the gradient operator to detect image edge, the final image block method and the Otsu method is used to determine the high and low threshold value, this algorithm achieved good result in noise filter, at the same time effectively removed noise disturbance, also completely retained the image edge details.

II. IMPROVED CANNY EDGE DETECTION ALGORITHM

A. Adaptive filtering

The first step of image edge detection is to smooth and filter the image. Adaptive filtering is adopted to improve the Canny algorithm. The adaptive filtering can not only effectively remove noise, but also effectively protect the edge information of the image[4].During image filtering, a large 5×5 image window is selected to calculate the minimum f_{min}, maximum f_{max} and median f_{med} of grayscale in the current template window. If satisfies $f_{min} < f_{med} < f_{max}$, and satisfies $f_{min} < f(x,y) < f_{max}$,indicates that the point is not a noise point, and the filtering output still is f(x,y). Otherwise, the window is reduced to a 3×3 window, and the number of pixel points n that are similar or equal to the gray value of the pixel point is counted. If $n \geq 4$, it means that this point is not an isolated spot, then this point is retained. If $3 \leq n < 4$, indicating that this point may be a noise point, which needs to be further distinguished. If this point and other points around it are three points continuous and in a straight line, this point is determined as the edge point, and the mean value of these three points is calculated as the gray value of this point. If n<3, This point is considered as noise point, which is directly removed and replaced by median f_{med}.

B. Calculation of directional gradient

The traditional Canny algorithm uses 2×2 finite difference to calculate the gradient value. In this paper, a 3×3 window of Sobel operator is used and 45° and 135° directions are added to calculate the gradient amplitude. This method can reduce the interference of noise[5]. Four gradient components I_x, I_y, I_{45} and I_{135} can be obtained by convolving the four directional cores with the denoised image respectively. Then, the gradient amplitude G(x, y) can be obtained by the operation of the four gradient components as shown in Formula (1), and the gradient direction θ(x, y) can be calculated by Formula (2). The formula is as follows:

$$G(\mathrm{x,y}) = \sqrt{I_x(\mathrm{x,y})^2 + I_y(\mathrm{x,y})^2 + I_{45}(\mathrm{x,y})^2 + I_{135}(\mathrm{x,y})^2} \tag{1}$$

$$\theta(\mathrm{x,y}) = \arctan\left[\frac{I_y(x,y)}{I_x(x,y)}\right] \tag{2}$$

$$\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \quad \begin{bmatrix} 0 & 1 & 2 \\ -1 & 0 & 1 \\ -2 & -1 & 0 \end{bmatrix}$$

(x) (y)

$$\begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \quad \begin{bmatrix} 2 & 1 & 0 \\ 1 & 0 & -1 \\ 0 & -1 & -2 \end{bmatrix}$$

(45) (135)

Figure 1. Four-directional template diagram

C. *Determination of thresholds*

In this paper, gray histogram segmentation is adopted to determine the selection of high and low thresholds. The image is divided into sub-blocks and combined with Otsu algorithm to more effectively select high and low thresholds for edge connection[6].

First, the non-maximum suppressed image is divided into non-overlapping 10×10 sub-blocks. For each sub-block of gradient image, the threshold values are determined by different methods according to the different histogram shapes. The histogram of image subblocks can be divided into three different forms. The number of pixel points M above 50 in the image block is calculated. If the ratio of M to the total number of pixel points in the image block is higher than 30%, it is considered as a transition block. For non-transition blocks, then calculate the number of pixels N with gradient greater than zero in the sub-block. If the ratio of N to the total number of pixels in the image block is higher than 20%, it is an edge block; otherwise, it is a smooth block[7].In order to achieve the best effect of edge detection, we use different methods to set thresholds for different sub-blocks, so as to improve the effect of image edge detection.

For the edge block, the mean value of the maximum and minimum value in the gray histogram is first calculated, which is denoted as the initial threshold. Then grey value is higher than the initial threshold and lower than the initial threshold is divided into two parts, respectively for two parts again average Z_1 and Z_2. Finally, the average value obtained is averaged, and the result obtained is compared with the initial threshold value. After multiple cycles of calculation[8], it stops until the results are similar or equal, and the final Z_1 and Z_2 are used as high and low thresholds.

For smooth piece, directly calculate grayscale histogram of the mean maximum and minimum values of Q, the average Q as a smooth piece of high threshold, the Q/2 as a low threshold. If the gradient values higher than the high threshold Q, think to the edge, then set by edge block threshold setting method, with average Q as smooth piece of high threshold, Q/2 as a low threshold.

For transition blocks, since their histogram range is relatively wide and the above method has large error. We use Otsu algorithm to determine the high and low thresholds[9].In this method, the gray histogram of the image is used to take the inter-class variance of the target and background as the measure criterion. When the measure criterion function takes the maximum value, the optimal threshold value is obtained[10].Assuming that the image has n pixel points, the probability of appearing gray value i is set as P_i. Threshold k divide the image into $C_1 = [1, 2,..., k]$ and $C_2 = [k+1, k+2,..., n]$ two kinds. The probability of C_1 and C_2 respectively as formula (3) and (4) shown below:

$$\omega_1 = \sum_{i=1}^{k} P_i \tag{3}$$

$$\omega_2 = \sum_{i=k+1}^{n} P_i = 1 - \omega_1 \tag{4}$$

The corresponding mean values are μ_1 and $\mu 2$, the gray value of the whole image is μ , and the inter-class variance formulas of the whole gray value and C_1 and C_2 are set as Formula (5) :

$$\begin{aligned} \sigma^2 &= \omega_1(\mu_1 - \mu)^2 + \omega_2(\mu_2 - \mu)^2 \\ &= \omega 1 \omega 2(\mu_2 - \mu_1)^2 \end{aligned} \tag{5}$$

According to Equation (5), when the maximum value is taken, the threshold k obtained is the optimal threshold. And the value higher than k is retained, and the value lower than the threshold k is smoothed[11].

III. EXPERIMENTAL RESULTS AND ANALYSIS

In order to detect the filter effect of the algorithm in this paper, the mean square error (MSE) and peak signal-to-noise ratio (PSNR) are used to make an accurate analysis. It can be seen from Figure 2 and 3 that compared with the traditional Canny algorithm and the algorithm in literature[9]. The Canny algorithm in this paper reduces MSE and makes the edge detection image more similar to the original image. At the same time, the PSNR is improved, and the image smoothing filtering effect is better[12].

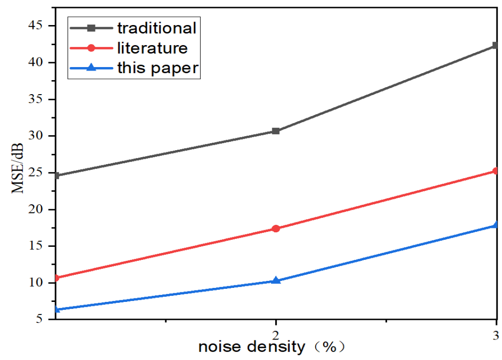

Figure 2. Comparison of MSE processed by different algorithms

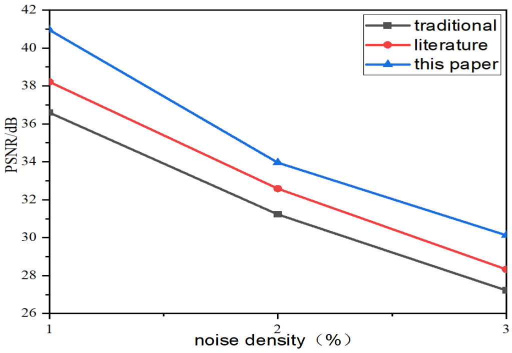

Figure 3. Comparison of PSNR processed by different algorithms

Verifing the effectiveness of the algorithm in this paper, the improved algorithm was used to compare different plant leaves with the traditional Canny algorithm and the algorithm in literature[9]. The comparison results are shown in Fig. 4. We can see from the picture, the traditional Canny algorithm can detect the basic outline of plant leaves, but the inside of the blades striped appeared partially missing. The algorithm in literature[9] detect image edge is more obvious, but the middle part of the edge part is not very clear. The improved algorithm to the edge of the blade and internal texture can clearly show that the effect is better. The traditional Canny operator is very sensitive to noise, and it is easy to treat the noise as the edge point and compare different blade images with 3% noise added. We can see from the fig.5, traditional Canny algorithm on the processing of the noise effect is poorer, noise didn't get effective treatment, basic algorithms in the literature, although it is a slight improve ment but effect is not ideal, there is still a lot of noise. The improved Canny operator has very good effect to restrain noise, can not only reduce the image noise and can avoid losing the real edge again. On the premise of guarantee outside the wheel profile complete, is also very good to keep the inner contour line, detect the edge image is superior to the traditional Canny algorithm and algorithm in the literature.

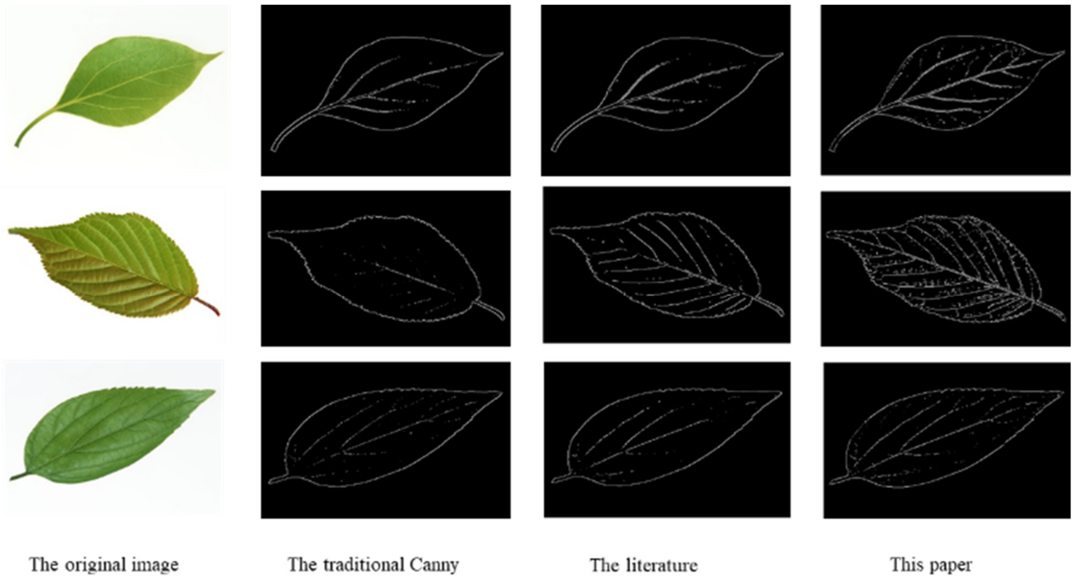

Figure 4. Different algorithm renderings of the original

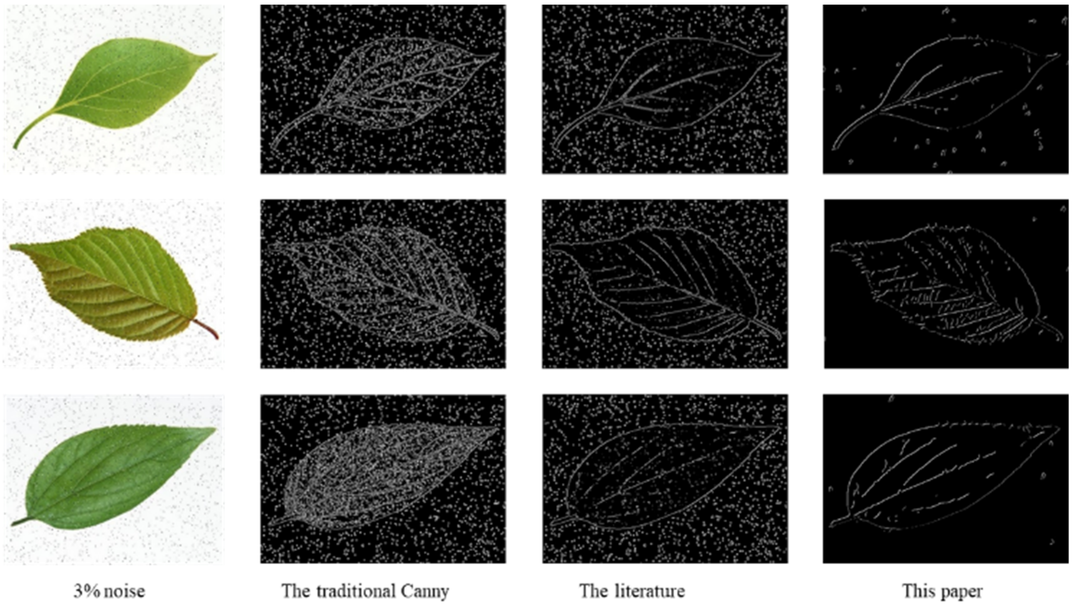

Figure 5. Renderings of different algorithms with added noise

IV. CONCLUSION

An adaptive filter is used to replace the original Gaussian filter in this paper. Secondly, the difference of the first derivative in the 3×3 neighborhood is used to replace the difference of the first derivative in the 2×2 neighborhood, and the gradient detection in the 45° and 135° directions is added on the basis of the original horizontal and vertical gradients. Finally, image block processing and Otsu method are used to effectively determine the figure threshold. Experiment results show that the proposed method solves the problem of edge information loss caused by the traditional Canny algorithm in the filtering process and the need to manually set the high and low threshold. It has a good effect on edge detection of plant leaf image in complex background.

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