An Improved Canny Edge Detection Algorithm

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Abstract—**The traditional Canny algorithm has been applied to image edge detection. However, this traditional algorithm can't adaptively determine the filtering threshold value and it can't separate targets from background, when filtering the lower contrast image. Therefore, in response to these problems, this paper proposed an improved method on Canny algorithm. Two adaptive thresholds were obtained by doing differential operation on amplitude gradient histogram. Then we connected edge points to get some generalized chains. After that, it needed to calculate their mean value to delete generalized chains, which are smaller than the mean value. Finally, the image edge detection results were got by linear fitting method. Experimental results show that the improved algorithm is more robust to noise and it can clearly separate targets from background.**

Keywords- edge detection; Canny algorithm; adaptive threshold; generalized chains; linear fitting method

I. INTRODUCTION

Digital image technology is widely used in image processing by extracting the edge detection to get the feature attribute of image. At present, many edge detection algorithms have been proposed, including Sobel, Robert operator, and Canny algorithm. Among these algorithms, Sobel and Robert operators are implemented through acquiring numerical difference method. Later, some new algorithms have proposed, such as ant colony optimization algorithm, ant colony optimization algorithm that based on k mean value and neural network method. In these algorithms, because Canny operator has good SNR (Signal-to-Nose Ratio), accurate edge location and unilateral response, so it is widely used in practice.

In 2010, the globalPb algorithm was proposed, its threshold is generated adaptively by system, so it can improve the anti noise ability of Canny algorithm. However, globalPb algorithm not only needs multi-scale and multi-information to compute the gradient, but also requires the additional spectral clustering to exclude the false edge. If these information cannot be provided, it will restrict the application in scene, which lacks texture information [1]. After that, an improved algorithm was proposed on it. This algorithm mainly wants to get the optimum solution of the maximal variance method by using adaptive particle swarm optimization [2]. In [3], it proposed an adaptive Canny algorithm for color image, which converts the RBG of color image into R-B chromatic aberration space graph, it needs to do integral arithmetic after Gaussian filtering. This method can connect the entire image edge. In [4], it puts forward an improved method based on Canny operator, it can achieve the positioning accuracy through the variance projection location algorithm. In order to improve the accuracy of edge detection, a morphological filtering algorithm is proposed to replace Gauss filtering, which can avoid manual intervention. This algorithm effectively resists salt and pepper noise[5-6]. In [7], it adopts the method of combining the global and local edge detection to extract the edges. In this way, it can obtain the complete image edges. There also has a Canny algorithm that is fused with the traditional motion objecting detection algorithm. This algorithm can effectively extract the foreground area of the image [8].

In this paper, we use median filter to smooth the image, and adaptively get double thresholds. After that, we link edge points and get the generalized chains, and we put forward a criterion on the generalized chains. In this way, it can eliminate false edge points, which have the approximate gray value with real edge points. Finally, the results of image edge detection are given by linear fitting method, and it makes the detection of image more adaptive and accurate.

II. THE TRADITIONAL CANNY ALGORITHM

A. Traditional Canny Algorithm Steps

Traditional Canny algorithm was divided into five steps:

1） Use Gauss function to smooth image.

2 ） Obtains the amplitude gradient and direction by differential operators.

3） Choose non-maximal value suppression method to get candidate edge points.

4） Check these candidate edge points by double thresholds.

5 ） Connect the rest candidate edge points, who are connected with edge points, and get the edge detection results of image.

B. Deficiencies of The Traditional Canny Algorithm

The Canny algorithm has widely used in image edge detection. However, it is still remaining three defects. The first one is that Gaussian filtering is sensitive to noise, and it is easy to produce isolated edge points. This leads to the generation of pseudo edge points. The second defect is that the value of the double thresholds are set fixed, so it cannot satisfy the algorithm's adaptability. The last one is that it only find whether there are edge points around them, when judging candidate edge points, this method will increase the number of

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pseudo edge points. For example, if there is a non edge point in the neighborhood of the candidate edge point, and it has the same gray scale value with edge point, it will misjudge the candidate edge points as edge points. This leads to an increasing number of false edges, and it causes the prospecting of the target to be submerged in the background image. In this paper, the median filter is used to replace the Gaussian filtering method, when smoothing image. Check candidate edge points through two adaptive thresholds, then connect them to form generalized chains. After that, we select generalized chains by rules to delete pseudo-edge points.

III. IMPROVED CANNY OPERATOR

A. Median filter algorithm

In this paper, median filter algorithm is used to replace Gaussian filtering method. The pixel value of a certain point in image is substituted by the median value in its neighborhood, this method not only reduces the influence of noise, but also can eliminate the isolated point [9].

Suppose the gray value of each point of the input digital image is $f(x,y)$, the filtering window is $M=(M_{mn})$, two-dimensional of the median filter function is $G(x,y)$:

$$G(x,y)=Med\left\{f(x+m,y+n)\middle|M_{mn}=1,(x,y)\in N\right\} \quad (1)$$

B. Adaptive real - time dual threshold algorithm

The adaptive real-time dual-threshold algorithm is implemented by making a differential operation on the amplitude histogram of the image. First, we need to find the maximum value of the central pixel in the same gradient direction by the non-maximum value suppression method, then the maximum value is processed by double threshold, if it is not a maximum value, the amplitude of the pixel is set to zero, and generate the gradient amplitude histogram as G_1. So the most important step is how to make the adaptive threshold. Its steps are as following: doing difference operation on the adjacent gradient amplitude:

$$G_1(i+1)-G_1(i) \quad (2)$$

Select the first zero of the amplitude as a high threshold, and the low value take 0.4 times of this high threshold, according to this rule, the adaptive threshold setting formulas are defined as:

$$Th_H=Arg\left(G_1(i+1)-G(i)=0\right) \quad (3)$$

$$Th_L=0.4Th_H \quad (4)$$

Where Th_H and Th_L stand for high threshold and low threshold. After determining the double threshold, the image is directly subjected to double threshold segmentation, when the non-maximum value is suppressed. $G_1(i,j)$ stands for the center pixel, and compares it with Th_H and Th_L. The discussion is divided into the following three cases:

First case:

$$G_1(i,j)>Th_H \quad (5)$$

it is defined that this pixel is strong edge point.

Second cases:

$$G_1(i,j)<Th_H \quad (6)$$

it is defined that this pixel is not edge point.

Third cases

$$Th_L<G_1(i,j)<Th_H \quad (7)$$

it is defined that this pixel is weak edge point. We take a closer filtering for these weak targets.

C. Formation and Filtering Generalized Chains

After comparison we have got strong and weak edge points. The next steps are as following:

Firstly, it need to find edge starting point, which is the maximum point and link it with weak edge points respectively. After that, the local maximum points are removed, which cannot be connected. In this way, we get edge chains. These chains are called generalized chains, which contains multiple lengths. The maximum length is set to $d_{\max}$, the minimum length is set to $d_{\min}$, we need to get average modulus threshold of these chains, its rule are as following:

$$\frac{d_{\max}+d_{\min}}{2}<d_{avrage}<d_{top} \quad (8)$$

Remove the gradient value, which smaller than d_{avrage}. The distribution of pseudo-edge points are decentralized, it can weaken the false strong edges through finding the mean of local maximum. And eliminate edge chains, which less than the d_{avrage}. So we effectively suppress the pseudo-strong edge points. The remaining points are the real edge points of image. Finally, we take the linear fitting method to get the result of the edge image.

IV. THE IMPROVED CANNY ALGORITHM

This algorithm is programmed in MATLAB, steps are as follows:

a): Use the median filter on the image preprocessing to get the image, and it is written as G.

b): Calculate the amplitude gradient. In order to obtain the amplitude gradient of the pixel, we use the horizontal and vertical templates to convolve the neighborhood of a pixel in the image. In this paper, we use 3×3 template to calculate the image gradient, that is shown as follows:

$$G_X=\begin{bmatrix}-1 & 0 & 1\\ -2 & 0 & 2\\ -1 & 0 & 1\end{bmatrix} \quad (9)$$

$$G_Y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \tag{10}$$

$$G_{x,y} = \begin{bmatrix} a_0 & a_3 & a_6 \\ a_1 & a_4 & a_7 \\ a_2 & a_5 & a_8 \end{bmatrix} \tag{11}$$

Where G_X and G_Y are respectively stand for horizontal pattern and vertical pattern. $G_{x,y}$ is pixel value of image.

The gradient magnitude and gradient direction of the central pixel are calculated as follows:

$$p_x = (a_6 + 2a_7 + a_8) - (a_0 + 2a_3 + a_6) \tag{12}$$

$$p_y = (a_6 + 2a_7 + a_8) - (a_0 + a_1 + a_2) \tag{13}$$

The gradient direction is calculated as follows:

$$G_1(i,j) = \sqrt{p_x^{\,2} + p_y^{\,2}} \tag{14}$$

$$\theta(i,j) = \arctan\left(p_x \big/ p_y \right) \tag{15}$$

c): We use non-maximum suppression to find the maximum value. Use (2), (3), (4) to get double thresholds, and compare them with maximum value of edge points to get initial edge points.

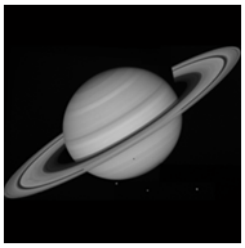
d): Select strong edge points as the edge of the starting point and link them with weak points to form edge chains, and calculate the average of edge chains by (8), then remove the generalized edge chains, which are smaller than the average of the gradient maximum of the image.

e): The linear fitting method is used, and get detection results of image.

V. EXPERIMENT AND ANALYSIS

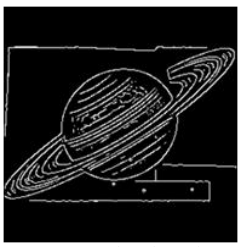
Choose Saturn, and the spaceship two pictures as the original image, in this paper, we respectively compare Sobel, Canny, with proposed improved Canny algorithm.

Taking this Saturn picture as the original figure, because its target is mostly in the highlight and central area. We check the results of the improved method.



(a) Original image

(b) Sobel edge detection



(c) Canny edge detection

(d) improved edge detection

Fig1. Saturn image segmentation comparison

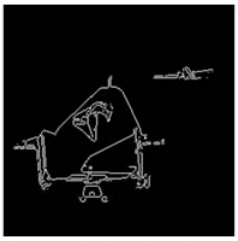
It can be seen that canny algorithm can get the edge of the image clear than Sobel algorithm, and the picture also has a sense of hierarchy for the canny algorithm from the Fig. 1(b) and (c). Compared the canny algorithm with the improved algorithm, we can see that the improved algorithm is more clear and delicate. It also has strong anti-noise ability, because it is not like the canny algorithm to link the non-marginal pixels, which are affected by the noise to misjudge as edge points. The improved algorithm is mainly to limit the value of the edge point, and filter them for second time.

The spacecraft is selected as the original image, because the background information of the image is larger and the background gray scale is same as the gray scale of the target. We still use the same algorithm for simulation and compare the results of them.

(a) Original image

(b) Sobel edge detection

(c)Canny edge detection



(d) improved edge detection

Fig2. Spacecraft image segmentation comparison

From Fig. 2(b), we can see that, it is not ideal to separate image backgrounds from target images by using Sobel algorithm. And the Canny algorithm is more poor in this situation, it is mainly because in the canny algorithm, the edge points are judged only by the neighborhood maximum. It is easy to misjudge the weak point to strong edge point. This will enlarge the background boundary and result in the foreground target of the image is submerged, when target and background have a similar gray value. The improved canny algorithm can be clearly separated the target from background of image, because it adopts the maximum point (including the strong edge points and weak edge points) to form generalized chains,

then filter them by the mean value of these chains. This method can improve the low threshold to delete the edge point, which is smaller than the mean value.

Through above two sets of simulation experiments proved that the improved algorithm is more adaptable and it also has strong anti-noise ability.

VI. CONCLUSION

The mean filter was introduced in this paper to replace Gaussian filtering method. This paper proposes an adaptive double thresholds, and it defines generalized chains, after that it need to calculate their mean value to filter themselves. The improved algorithm not only has the advantages of the Canny algorithm, but also improves the anti-noise ability, and keeps the edge image more clearly.

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