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Based on the research of improved edge detection algorithm

Wang Jie[1] and Cui Mina[2]

[1]*Institute of Courses and Teaching Theory Research, Jilin Normal University, Siping 136000, Jilin Province, China*
[2]*The Information Center of Xing Longtai Oil Production Plant of Liaohe Oil Field, Panjin 124011, Liaoning Province, China)*
wj3291948@126.com

Abstract

Analysis and several common edge detection algorithm is improved, and put them in the original experiment results were compared with the results in this paper, we defined the new threshold, fully explained in this paper, we define the rationality and validity of the threshold value. Kirsch of traditional algorithm was improved, and improve the efficiency of the algorithm, and verify the rationality of the defined threshold and improve the ability to suppress noise.

Keywords: *Image processing, Edge detection, Image enhancement, Image zoom and shrink*

1. Introduction

Image in human perception plays a very important role, human anytime to contact images (except for the blind). According to statistics, in the human accept information, visual information more than 70%. What is called "seeing is believing", on many occasions, the image information transfer by richer and more true than any other form. Thus, image information is very important [1]. Image (Image) is used in a variety of observation system, able to perception by the human visual system entities. Human visual system itself is also an observation system, it is the objective scenery image is visible in the eyes of people imagine. Image range is very wide, including: all kinds of pictures (Picture), such as ordinary images, x-rays, remote sensing images; All kinds of optical image, such as movies, television images; The objective world in the eyes of people physical imagination and external description, such as painting, drawing; And so on. Digital image is to point to, using the computer for processing and processing. Digital image processing technology that originated in the 1920 s, the use of digital compression technology, through the cable from London transport a photograph to New York in the United States. In the 1950 s, people began to study on system of digital image processing technology. Of the jet propulsion laboratory in 1964, the United States, California, using a digital computer, dealt with the spacecraft "traveler 7" bring back pictures of the moon, it is an important milestone in digital image processing, marks the third generation of computer digital image processing the concept began to get application. Followed by digital image processing technology is developing rapidly, in the early 1970 s, digital image processing has formed a relatively perfect system of discipline, and become an independent discipline.

Digital image processing has a very wide range of knowledge involved, there are many different kinds of specific methods. Traditional image processing techniques are mainly concentrated in the image acquisition, enhancement, restoration and

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transformation (reduction), compression coding, segmentation and edge detection, *etc.*, and with new tools, new methods appear constantly, the image processing technology has also been updated and development.

Image edge is one of the basic characteristics of the image, it contains valuable to human vision and machine vision image information of object. Edge is the image features, such as the pixel, texture, *etc.*) distribution is discontinuous, image characteristics have a step change or roof change around the collection of pixels. Image edge exists in the goals and objectives, targets and the background, primitive and the boundary of the primitive, it identifies the target object or the actual content of the primitive, is the largest concentration of image identification information. Image edge detection is an important content of image analysis, it is also an important image processing field pretreatment technology, widely used in the outline, feature extraction and texture analysis, *etc*. People do a lot of research work in this respect, and put forward a lot of algorithm, the commonly used edge detection methods have difference operator method, generalized Hough transform method, optimal curve fitting method, etc. Normally, generally refers to the pixels in the image edge gradient between those pixels of maximum value, they said the brightness of discontinuous area. But in practice, because of the noise, the edges of the uneven illumination and other factors, it is difficult to accurately determine the edge position. Edge detection algorithms, before people often used the same test template or operator operations to the whole image, such as Sobel, Prewitt, Robert, Kirsch, Robinson, Laplacian operator belong to this kind of method, such as the characteristics of this kind of method is simple operation, can be parallel processing, the disadvantage is that is sensitive to noise, the edge is rough. Another kind of method is in view of the local area or the whole image to determine a threshold, the image segmentation, so as to extract the edge. This kind of method of the key is how to determine one or more of the threshold will extract edges effectively. To solve these problems, people carried out considerable research, and put forward many improved measures [2-4], some find by double threshold image f (x, y) method to get the edge information of local maximum of gradient, but did not consider the human eye vision features, easy to take the noise points as edges, also easy to throw in the weak edge, and the computation is big, can't meet the requirements of real-time image processing [5]. There are some ways use wavelet method for edge detection, but smooth, symmetry, compact support wavelet function is difficult, because they did not consider the human eye visual features, determine the noise and the noise points also easy, and the computational complexity is also quite big. Canny method [6] is now one of the ideal edge detection algorithms, has become a measure of quality of other algorithms, the Canny algorithm is sensitive to noise, and the need for the maximum inhibition, edge connection operation, such as computational complexity is very big, not suitable for real-time image processing system. Therefore, design a kind of noise suppression capability, parallel processing, fast computing speed, can automatically generate threshold, edge detection algorithm and edge more fine is imperative.

2. Related Works

Any pair of perpendicular direction difference can be seen as gradient approximation method, Roberts edge detection operator by using the principle of the diagonal direction of the difference of the two adjacent pixels instead of gradient, that is:

1) calculate the gradient

$$f_x = f(i, j) - f(i+1, j+1) \quad (1)$$

$$f_y = f(i, j+1) - f(i+1, j) \quad (2)$$

f_x and f_y the convolution operator as follows:

$$f_x : \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \text{ and } f_y : \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$$

2) Calculate the gradient amplitude

Gradient amplitude as follows:

$$R(i, j) = \sqrt{f_x^2 + f_y^2} \quad (3)$$

Or approximation for:

$$R(i, j) = |f_x| + |f_y| \quad (4)$$

Robert operator can be obtained by difference in difference point (I + 1/2, j + 1/2) continuous gradient amplitude approximation R (i, j). Selecting appropriate threshold tau, if R (i, j) > tau, argues that point (i, j) is the edge points.

Robert edge detection operator with diagonal direction of the difference of the two adjacent pixel gradient amplitude detection, the detection performance is better than the diagonal lines on the edge of the horizontal and vertical direction the direction of edge, and the detection precision is higher, but is sensitive to noise.

3) Robert defects of the algorithm

(1) the traditional edge detection operator, Robert using gradient of diagonal direction to the difference between the adjacent pixels detection, without considering the situation of the horizontal and vertical adjacent pixels adjacent pixels, and is more sensitive to noise.

(2) the traditional edge detection operator, Robert cannot eliminate local noise interference on one hand, on the other hand will lose the local edge of grey value changes slowly, leading to the target object contour edge discontinuity. In addition, because the traditional threshold of Robert operator is not determined by the image features of information, but need to be artificial, therefore, the low degree of automation.

(3) the edge while is fine, but is not enough for special occasions.

Improved Robert edge detection algorithm proposed in this paper on the three defects of the traditional algorithms of Robert improvement, has obtained the good experimental effect.

3. The Improved Robert Edge Detection Algorithm

3.1. Improve the Calculation Method of the Image Gradient Amplitude

In view of the traditional algorithms of Robert defects on gradient amplitude calculation, this paper puts forward a kind of pixels within 8 neighborhood through calculating horizontal (0^0) direction, vertical direction (90^0), the direction 135^0, the

direction of 45^0 first order partial derivative method of finite difference to determine pixel gradient amplitude, and increase the value, direction 45^0 and the direction 135^0 in this way, both the gradient amplitude calculation edge positioning accuracy and noise, good effect is obtained in the experiment, a specific algorithm is as follows:

Horizontal partial derivative: $P_0[i, j] = I[i-1, j] - I[i+1, j]$ (5)

Vertical partial derivative: $P_{90}[i, j] = I[i, j-1] - I[i, j+1]$ (6)

The direction 135^0 of partial derivative $P_{135}[i, j] = 2 \times (I[i-1, j-1] - I[i+1, j+1])$ (7)

The direction 45^0 of partial derivative $P_{45}[i, j] = 2 \times (I[i+1, j-1] - I[i-1, j+1])$ (8)

Their corresponding convolution operator as follows:

$$p_0: \begin{bmatrix} 0 & 0 & 0 \\ 1 & 0 & -1 \\ 0 & 0 & 0 \end{bmatrix} \quad p_{90}: \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & -1 & 0 \end{bmatrix} \quad p_{135}: \begin{bmatrix} 2 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -2 \end{bmatrix} \quad p_{135}: \begin{bmatrix} 0 & 0 & 2 \\ 0 & 0 & 0 \\ -2 & 0 & 0 \end{bmatrix} \tag{9}$$

The pixel gradient amplitude and gradient direction using rectangular to polar transformation formula to calculate, quadratic norm can be used to calculate the gradient amplitude as follows:

$$M(i, j) = \sqrt{P_0^2[i, j] + P_{90}^2[i, j] + P_{135}^2[i, j] + P_{45}^2[i, j]} \tag{10}$$

Can be simplified as:

$$M[i, j] = |P_0[i, j]| + |P_{90}[i, j]| + |P_{135}[i, j]| + |P_{45}[i, j]| \tag{11}$$

2) automatic threshold method

Against traditional Robert algorithm in setting the flaws of the fixed threshold, a kind of automatically generating threshold method is proposed, based on the literature [7] of the two-dimensional threshold segmentation algorithm application of neighborhood average gray level of thought, here also use 3 x3 neighborhood to automatic calculation for testing point of the average threshold:

$$x = \frac{1}{9} \times \sum_{i=0}^{2} \sum_{j=0}^{2} I(i, j) \tag{12}$$

If using fixed threshold, the false edge, set of small prone to set up the big easy to make the edge discontinuity; In this paper, considering the human visual system of "Weber's Law" (Weber 's Law) or gray feature, automatic calculation threshold.

3.2. Edge Thinning

1) [8] of the thinning algorithm

Set up the image in the target for 1 background point marking is 0, define the edge points of itself is marked as 1 and the field of 8 connected at least one point mark to zero point, refinement algorithm for edge point in the document [9] does the following:

(Ⅰ) considering 8 neighborhood of the edge points as the center q_q, center for the neighborhood's eight points clockwise around the center, respectively is: remember q_0,

q_1, q_2, …, q_7, which q_0 in the upper left q_q. First of all the edges of the tags at the same time satisfy the following conditions:

(1.1) $2 \le N(q_q) \le 6$ (1.2) $S(q_q) = 1$

(1.3) $q_1 \times q_3 \times q_5 = 0$ (1.4) $q_3 \times q_5 \times q_7 = 0$

$N(q_q)$ is the center of the number of non-zero adjacent points q_q, $S(q_q)$ is q_0, q_1, q_2, …, q_7, for the sequence of these points when the number of changes in value from 0 to 1, after the inspection to all the edge points, delete all the marked points.

(Ⅱ) then tag edge points and to satisfy the following conditions:

(2.1) $2 \le N(q_q) \le 6$ (2.2) $S(q_q) = 1$

(2.3) $q_1 \times q_3 \times q_7 = 0$ (2.4) $q_1 \times q_5 \times q_7 = 0$

When the same for all the edge points after the inspection, will be deleted all the marked point.

Above, two step constitutes an iterative algorithm of iterative until there is no point to meet mark condition, then the rest of the points are the refinement algorithm to obtain the image of single pixel edge. In all tags conditions mentioned above, the condition (1) q_q remove the only 1 marked as 1 point, is the line segment endpoint and seven marked as 1 of adjacent points, namely q_q the region is too deep; Conditions (2) to remove q_q the line segment of width for a single pixel operations to avoid the situation of edge will be cut off; Condition (3) and (4) removed to the right or on the edge of the endpoint($q_3 = 0$ or $q_5 = 0$) or the upper left corner point ($q_1 = 0$ and $q_7 = 0$) that is not the edge point; Similarly, condition (3) and (4) remove the to the left or on the edge of the endpoint ($q_1 = 0$ or $q_3 = 0$) or the lower right corner point ($q_5 = 0$ and $q_7 = 0$), which is not of edge points, the final notice, such as the edge of the upper right endpoints were ($q_1 = 0$ or $q_3 = 0$), such as the edge of the left endpoint has ($q_5 = 0$ and $q_7 = 0$), they are all at the same time satisfy (3) and (4) the conditions.

2) algorithm of defects in literature [8]

(1) kept isolated point. Because of the conditions in the document [9] (1), (2) requirements $2 \le N(q_q) \le 6$, q_q is the center of the number of non-zero adjacent point is greater than or equal to 2 and less than or equal to 6, and isolated points by the number of non-zero adjacent point is zero, does not meet the condition (1) and (2), isolated point has not been deleted, and isolated points is likely to be noise.

(2) the computation Hypothesis testing point meet the conditions (1) and (2) q_1、q_3、q_5, 1, 0. The needs 8 multiplication (or and operation) (note: the type of q_0, q_1, q_2, …, q_7 the value of the only two value '0' and '1', ‘ × ’ here can is multiplication and operation).

3) In ref. [8] analysis and improvement of the algorithm

Close analysis of the literature [8] of the thinning algorithm for a pixel is to satisfy the conditions q_q in the (Ⅰ) be deleted, or meet the conditions of the (Ⅱ) be deleted, no

difference; Conditions (1), (2) and (2.1), (2.2), the same conditions (1.1) or (2.1) for the number of non-zero adjacent point is greater than or equal to 2 and less than or equal to 6, conditions (1.2) or (2.2) for the non-zero neighboring points in,,,... Is continuous, the sequence (, because it is over, so q_0, q_1, q_2, ⋯, q_7 is 1 in the sequence, $S(q_q)=1$, q_0, q_1, q_2, ⋯, q_7, must be a continuous), obviously if conditions (1.2) or (2.2), is the zero point is continuous, and the number of neighboring points 0 is greater than or equal to 2 and less than or equal to 6, so at least one zero point, $S(q_q)=1$,. Suppose in meet the condition (1.1) and (1.2) or (2.1) and (2.2) under the premise of, the condition (2.3) and (2.4) are satisfied, you should delete; Similarly, when or conditions (1.3), (1.4) met, when conditions (2.3), (2.4). So as long as the conditions (1.1), (1.2) or (2.1) and (2.2), the point must be deleted, and don't have to consider condition (1.3), (1.4) or (2.3) and (2.4).

Through the above analysis, the condition (1.3), (1.4) and (2.3), (2.4) is redundant, conditions (1.1), (1.2) and (2.1), (2.2), the same one.

So in document [8] of the thinning algorithm is improved as follows:

(1) If $N(q_q)=0$, which are removed.

(2) if $2 \le N(q_q) \le 6$ and $S(q_q)=1$, the delete that point.

Above two step constitute an iteration, the second step is iterated until there is no point to meet mark condition, then the rest of the points are the refinement algorithm to obtain images of single pixel edge (one iteration can remove noise point, so the first step do not need to be repeated iteration).

Because different image edge thinning of each edge point arrangement is not exactly the same, under the premise that out $N(q_q)$ and $S(q_q)$, in the worst case, the algorithm need more operation in document [8] 10 times (note: two conditions (1.1), (1.2), (1.3), (1.4) 1 times; condition 2.1 to 2.4 with 2.1 2.4), multiplication (or with operation) 8 times; In the best case, comparison operations, 5 times multiplication (or with operation) 3 times; Improved algorithm under the condition of without considering isolated points, the best and the worst, only need three comparison operation, multiplication 0 times. The computing complexity as shown in Table 1:

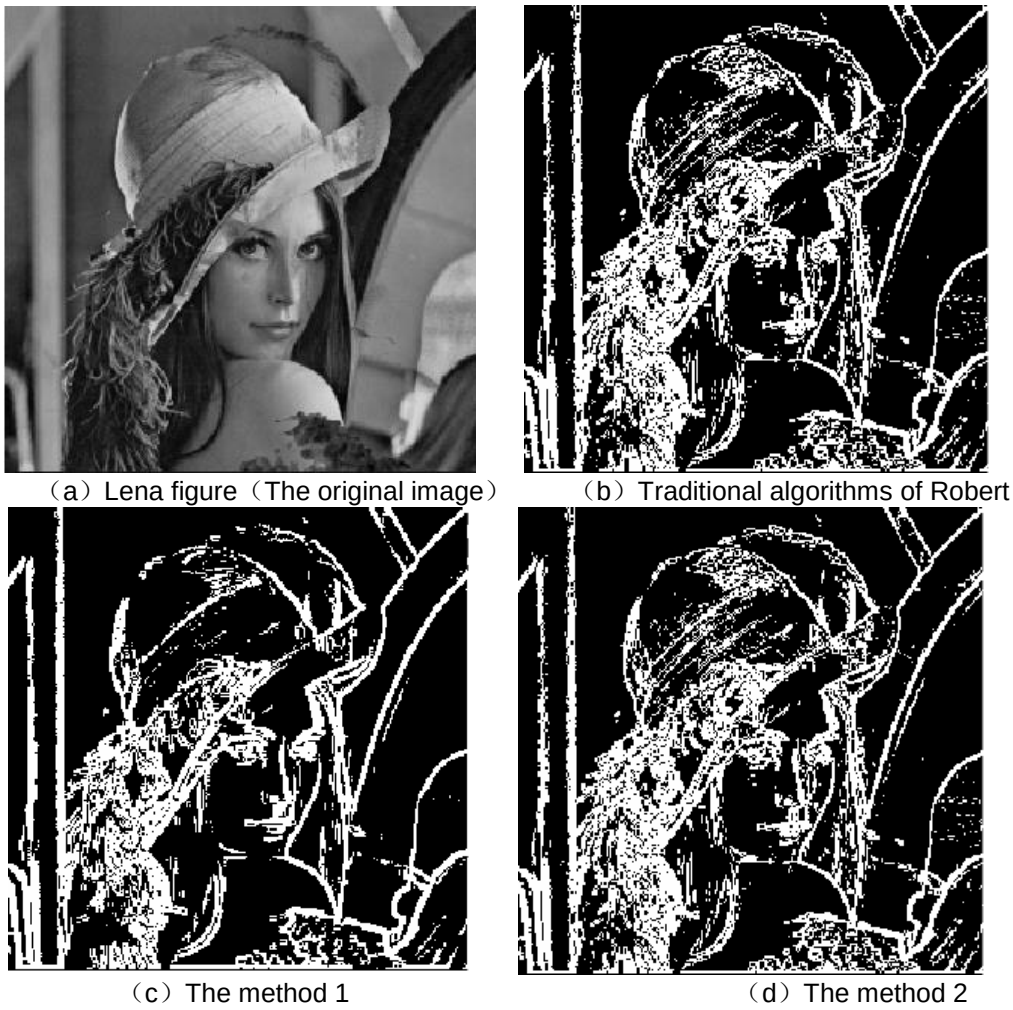
Table 1. Comparison of Two Kinds of Algorithm Complexity

Testing point condition	Comparison operations	multiplication	Refinement algorithm
Best	5	3	The former algorithm
Worst	10	8	The former algorithm
Best	3	0	The improved algorithm
Worst	3	0	The improved algorithm

From Table 1 shows the complexity of the improved algorithm than improve the complexity of the algorithm to reduce many times before. The improved algorithm is the essence of the algorithm in the document [8] is analyzed and improved, only increased the efficiency does not change or affect the results of the original algorithm.

4. Simulation Results and Analysis

This paper with the traditional Robert algorithm, based on the characteristics of the human eye vision in the visual areas of high resolution, the threshold value should be smaller, because the human eye is easy to distinguish their different), the area of low resolution, the vision threshold should be larger (because the human eye is not easy to distinguish their different), that is to say the same gray level difference, in different regions of some edge is considered, some are considered not edge. To thinning algorithm, the three conditions of Lena image edge detection experiments, the experimental results are shown in Figure 1 and Figure 2:



（a）Lena figure（The original image）　（b）Traditional algorithms of Robert

（c）The method 1　（d）The method 2

Figure 1. Lena Image Edge Detection Results

In Figure 1 of three kinds of edge detection algorithm for image edge detection used in this paper, the refine edge thinning algorithm, the result is shown in Figure 2.

（a）Algorithms of Robert

（b）Method1

（c）Method2

Figure 2. Lena Image Edge Detection Results

For containing gaussian white noise (averages mu = 0, variance of sigma = 20) of Lena image (other parameters are fixed,)redo the above experiment result is shown in Figure 3:

（a）LenaFigure（include noise）

（b）Traditional algorithms of Robert


（c）Method1


（d）Method2

Figure 3. Lena Image Edge Detection Results

By comparing the results of Figure 1 and Figure 2 analysis shows that traditional Robert before no thinning algorithm, the traditional algorithms of Robert just some noise in the image is more, the characters on the right side of the face at the bottom of the edges, Robert traditional algorithm, and using the threshold algorithm of this part of the edge is smooth and continuous, it shows that the formulas in this paper, we define threshold algorithm to get the threshold, can detect weak edges; After thinning algorithm for thinning them in practical writing, it can be seen in the original image on the left edge of the white columns under three kinds of algorithms have significantly different effect, this part of the traditional algorithms of Robert very rough edge is not smooth, using the improved Robert operator but not the effect of using the new threshold algorithm is much better than the traditional algorithms of Robert. This shows that the effect of improved Robert operator is better than the effect of the original Robert operator, by comparing the results of figure 3 analysis shows that the traditional Robert algorithm is sensitive to noise, and improve Robert operator to noise has certain inhibition; Through the elaboration on them the effect after the comparison, can be similar to Figure 1 and Figure 2 of the conclusion. This fully shows that the improved Robert algorithm compared with the original Robert algorithm has better performance.

Improved Robert operator has the ability to restrain noise can be seen from the operator of the template structure, traditional Robert operator for testing point directly involved in the operation, and improvement of Robert operator to check points corresponding to the weight of '0', is its 8 neighborhood by gradient amplitude, so it is not sensitive to noise and due consideration to the human visual characteristic, and can further reduce the impact of noise, and can detect weak edges. To get the edge image with the refinement algorithm are realized in this paper, single pixel edge can be obtained.

5. Conclusion

Analysis and several common edge detection algorithm is improved, and the former experimental results of them respectively. And use are compared in this paper, we define a new threshold results, fully illustrates the definition of the rationality of the threshold and have effect, in which the traditional Robert algorithm to improve its ability to suppress noise; To improve the efficiency of the algorithm to verify the rationality of the defined threshold, improve the efficiency of the algorithm, and improved the ability to suppress noise.

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Authors

Wang Jie, Jie received the B. S. degree in Mathematics Department from Siping Teachers' College and the M. Ed. degree from Mathematics College of Northeast Normal University (NENU) in 1993 and 2000 respectively. Her current research interests on the theory and application of edge detection algorithm and numerical algorithm.

Cui Mina, received the B. Eng degree in automation from Liaoning Shihua University and the M. Eng degree in Project Management from Dalian University of Technology in 2002 and 2009 respectively. She is currently researching on IT Project Progress Plan and Control.

