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Binary Morphology Operator To Extract Binary Edge Of An Image

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Abstract*− *Mathematical morphology (MM) is a theory and technique for the analysis and processing of geometrical structures, based on set theory, lattice theory, topology, and random functions. MM is most commonly applied to digital images, but it can be employed as well on graphs, surface meshes, solids, and many other spatial structures. If this mathematical morphology is applied to the binary image or itself a gray scale image then that is called the binary morphology. Digital image Processing is one of the basic and important tool in the image processing and computer vision. In this paper we discuss about the extraction of a digital image edge using different digital image processing techniques. Edge detection is the most common technique for detecting discontinuities in intensity values. The input image or actual image may have some noise that may cause the quality of the digital image. Firstly, wavelet transform is used to remove noises from the image collected. Secondly, some edge detection operators such as Differential edge detection, Log edge detection, canny edge detection and Binary morphology are analyzed. And then according to the simulation results, the advantages and disadvantages of these edge detection operators are compared. It is shown that the Binary morphology operator can obtain better edge feature. Finally, in order to gain clear and integral image profile, the method of ordering closed is given. After experimentation, edge detection method proposed in this paper is feasible.

Index terms-DigitalImageEdge detection, wavelet de-noising, differential operators, and binary morphology.

I. INTRODUCTION

An edge in a digital image is a boundary or contour at which a significant change occurs in some physical aspect of an image, such as the surface reflectance, illumination or the distances of the visible surfaces from the viewer. Changes in physical aspects manifest themselves in a variety of ways, including changes in color, intensity and Texture. Edge always indwells in two neighboring areas

having different grey level. It is the result of grey level being discontinuous. Edge detection is a kind of method of image segmentation based on range non-continuity. Image edge detection is one of the basal contents in the
image processing and analysis, and also is a kind of issues which are unable to be resolved completely so far. When image is acquired, the factors such as the projection, mix, aberrance and noise are produced. These factors bring on image feature is blur and distortion, consequently it is very difficult to extract image feature. Moreover, due to such factors it is also difficult to detect edge.

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The method of image edge and outline characteristic's detection and extraction has been research hot in the domain of image processing and analysis technique.Detecting edges is very useful in a number of contexts. For example in a typical image understanding task such as object identification, an essential step is to an image into different regions corresponded to different objects in the scene. Edge detection is the first step in the image segmentation. Edge feature extraction has been applied in many areas widely. This paper mainly discusses about advantages and disadvantages of several edge detection operators applied in the cable insulation parameter measurement. In order to gain more legible image outline, firstly the acquired image is filtered and de=noised. In the process of de-noising, wavelet transformation is used. And then different operators are applied to detect edge including Differential operator, Log operator, canny operator and Binary morphology operator. Finally the edge pixels of image are connected using the method of bordering closed. Then a clear and complete image outline will be obtained

II. IMAGE DENOISING

As we all know, the actual gathered images contain noises in the process of formation, transmission, reception and processing. Noises deteriorate the quality of the image. They make image blur. And many important features are covered up. This brings lots of difficulties to the analysis. Therefore, the main purpose is to remove noises of the image in the stage of pretreatment. The traditional de-noising method is the use of a low-pass or band-pass filter to de-noise. Its shortcoming is that the signal is blurred when noises are removed. There is irreconcilable contradiction between removing noise and edge maintenance. Yet wavelet analysis has been proved to be a powerful tool for image processing. Because Wavelet de-noising uses a different frequency band-pass filters on the signal filtering. It removes the coefficients of some scales which mainly reflect the noise frequency. Then the coefficient of every remaining scale is integrated for inverse transform, so that noise can be suppressed well. So wavelet analysis widely used in many aspects such as image compression, image de-noising,etc

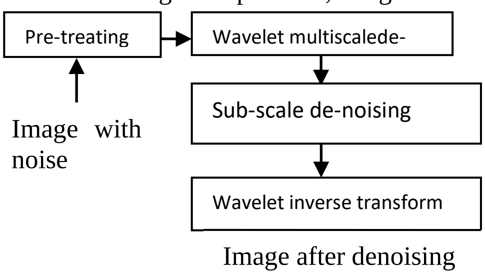

Fig. II.1. Wavelet de-noising

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The basic process of de-noising making use of wavelet transform is shown in Fig II.3, its main steps are as follows:

1. Image is preprocessed (such as the gray-scale adjustment, etc.).
2. Wavelet multi-scale decomposition is adapted to process image.
3. In each scale, wavelet coefficients belonging to noises are removed and the wavelet coefficients are remained and enhanced.
4. The enhanced image after de-noising is gained using wavelet inverse transform.

The common used operators are the Differential, Log, Canny operators and Binary morphology, etc.The simulation effect of wavelet de-noising through Mat lab is shown in Fig.II.3.

Fig. II.2. Image with noise

Fig. II.3. Image after denoising

Comparing with the traditional matched filter, the high-frequency components of image may not be destroyed using wavelet transform to de-noise. In addition, there are many advantages such as the strong adaptive ability, calculating quickly, completely reconstructed, etc. So the signal to noise ratio of image can be improved effectively making use of wavelet transform.

III. EDGE DETECTION TECHNIQUES

The edge detection of digital image is quite important foundation in the field of image analysis including image division, identification of objective region and pick-up of region shape and so on. Edge detection is very important in the digital image processing, because the edge is boundary of the target and the background. And only when obtaining the edge we can differentiate the target and the background.The basic idea of image detection is to outstand partial edge of the image making use of edge enhancement operator firstly. Then we define the 'edge intensity' of pixels and extract the set of edge points through setting threshold. But the borderline detected may produce interruption as a result of existing noise and image dark.

Thus edge detection contains the following two parts:

1) Using edge operators the edge points set are extracted.
2) Some edge points in the edge points set are removed and a number of edge points are filled in the edge points Set. Then they obtained edge points are connected to be a line.

1. Differential operator

Differential operator can outstand grey change. There are some points where grey change is bigger. And the value calculated in those points is higher applying derivative operator. So these differential values may be regarded as relevant 'edge intensity' and gather the points set of the edge through setting thresholds for these differential values. First derivative is the simplest differential coefficient. Suppose that the image is $f(x, y)$, and its derivative operator is the first order partial derivative $\partial f/\partial x$, $\partial f/\partial y$. They represent the rate-of-change that the gray f is in the direction of x and y. Yet the gray rate of change in the direction of α is shown in the equation (1):

$$\frac{\partial f}{\partial \alpha} = \frac{\partial f}{\partial x} cos\alpha + \frac{\partial f}{\partial y} sin\alpha \ldots\ldots.. (1)$$

Under consecutive circumstances, the differential of the function is:

$$df = \frac{\partial f}{\partial x} dx + \frac{\partial f}{\partial y} dy.$$

The direction derivative of function f (x, y) has maximum at a certain point. And the direction of this point is arc tan $[\frac{\partial f}{\partial y} / \frac{\partial f}{\partial x}]$. The maximum of direction derivative is $\sqrt{\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2}$.the vector with this direction and modulus is called as the gradient of the function f, that is, $\nabla f = (\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y})$.So the gradient modulus operator is designed in the equation (2).

$$G[f(x,y)] = \sqrt{\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2} \ldots\ldots\ldots (2)$$

For the digital image, the gradient template operator is designed as:

$$\sqrt{(\Delta_x f(i,j)^2 + \Delta_y f(i,j)^2} \ \ldots\ldots\ldots.. \quad (3)$$

$$\Delta_x f(i,j) = f(i,j) - f(i-1,j),$$

$$\Delta_y f(i,j) = f(i,j) - f(i,j-1),$$

Differential operator mostly includes Roberts's operator and Sobel operator.

2. *Roberts operator:*

Roberts's operator is a kind of the simplest operator which makes use of partial difference operator to look for edge. Its effect is the best for the image with steep low noise. But the borderline of the extracted image is quite thick using the Roberts operator, so the edge location is not very accurate. Roberts's operator is defined as:

$$G[f(x,y)] = (\{[f(x+1,y+1) - f(x,y)^2\,] + [f(x+1,y) - f(x,y+1)^2\,\}\,)^{1/2} \ \ldots\ldots\ldots. (4)$$

But absolute deviation algorithm is usually used to predigest the equation (4) in practice. The following equations (5) and (6) are the process of reduction.

$$G[f(x,y)] \approx |f(x+1,y) - f(x,y)| + |\,f(x,y+1) - f(x,y)| \quad \ldots\ldots..(5)$$

$$G[f(x,y)] \approx |f(x+1,y+1) - f(x,y)| + |\,f(x,y+1) - f(x+1,y)| \quad \ldots\ldots.... (6)$$

The template of the Roberts operator is shown in Fig. III.2.1.

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0	1
-1	0

1	0
0	-1

Fig. III.2.1 Roberts Operator

Sobel and Prewitt operator

To reduce the influence of noise when detecting edge, the Prewitt operator enlarges edge detection operator template from two by two to three by three to compute difference operator. Using the Prewitt operator can not only detect edge points, but also restrain the noise. The Sobel operator counts difference using weighted for 4 neighborhoods on the basis of the Prewitt operator. The Sobel operator has the similar function as the Prewitt operator, but the edge detected by the Sobel operator is wider. Suppose that the pixel number in the 3×3 sub-domain of image is as follows:

A_0	A_1	A_2
A_7	f(x, y)	A_3
A_6	A_5	A_4

We order that

$X = (A_0+2A_1 +A_2) - (A_6+2A_5+A_4)$

And $Y = (A_0+2A_7 +A_6) - (A_2+2A_3+A_4)$.

Then Prewitt operator is as follows:

$G\,[f\,(i, j)] = (\sqrt{X^2+Y^2})$ …… (7)

$G\,[f\,(i, j)] = /X/+/Y/$ ……. (8)

Prewitt operator is said in Fig III.3.1. in the form of the template.

1	1	1
0	0	0
-1	-1	-1

1	-1	1
1	-1	0
1	-1	-1

Fig. III.3.1 Prewitt operator

Sobel operator can process those images with lots of noises and gray gradient well. We order that

$X = (A_0+2A_1+A_2) - (A_6+2A_5+A_4)$

And $Y = (A_0+2A_7+A_6)-(A_2+2A_3+A_4)$ SS

Then Sobel operator is as follows:

$G\,[f\,(i, j)] = (\sqrt{X^2+Y^2})$ ….. (9)

$G\,[f\,(i, j)] = /X/+/Y/$ ….. (10)

The templates of Sobel operator is shown in fig.III.3.2.

1	2	1
0	0	0
- 1	-2	-1

1	0	-1
2	0	-2
1	0	-1

Fig. III.3.2 Sobel Operator

The original image of cable insulation layer and the edge detection drawing of Sobel operator gained using Mat Lab simulation are shown in Fig. III.3.3

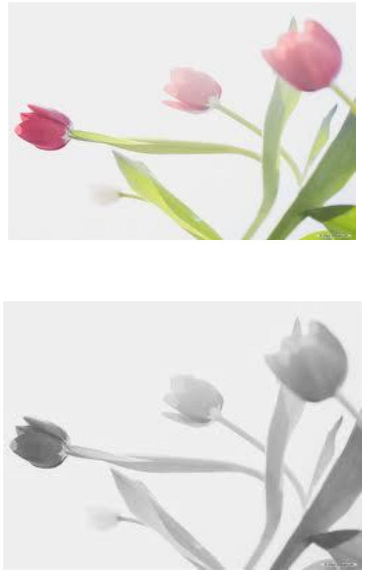

Fig. III.3.3 .Original image and Gray scale image

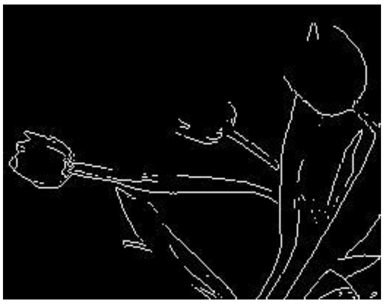

Fig. III.3.4 Edgeextracted by Sobel operator

From the simulation drawing figure. We can know that the edge position is very accurate. And the effect of Sobel edge detection is very satisfying. In a word, the Sobel and Prewitt operators have a better effect for such images with grey level changing gradually and more noises.

III. 4 . Log operator

The Log operator is a linear and time-invariant operator. It detects edge points through searching for spots which two-order differential coefficient is zero in the image grey levels. For a continuous function f (x, y), the Log operator is defined as at point (x, y):

$$\Delta^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \text{ ………..} \quad (11)$$

The Log operator is the process of filtering and counting differential coefficient for the image. It determines the zero overlapping position of filter output using convolution of revolving symmetrical Log template and the image. The Log operator's template is shown in Fig. III.4.1

-1	-1	-1
-1	8	-1
-1	-1	-1

0	-1	0
-1	4	-1
0	-1	-1

Fig. III.4.1 Log operator

In the detection process of the Log operator, we firstly pre-smooth the image with Gauss low-pass filter, and then find the steep edge in the image making use of the Log operator. Finally we carry on binarization with zero grey level to give birth to closed, connected outline and eliminate all internal spots. But double pixels boundary usually appears using the Log operator to detect edge, and the operator is very sensitive to noise. So the Log -operator is often employed to judge that edge pixels lie in either bright section or dark section of the image.

III. 5. Canny operator

The Canny operator is a sort of new edge detection operator. It has good performance of detecting edge, which has a wide application. The Canny operator edge detection is to search for the partial maximum value of image gradient. The gradient is counted by the derivative of Gauss filter. The Canny operator uses two thresholds to detect strong edge and weak edge respectively. And only when strong edge is connected with weak edge, weak edge will be contained in the output value. The theory basis of canny operator is shown in equations (12)-(15)

Gauss:

$$G(x, y) = \exp[-(x^2 + y^2)/2\sigma^2] \quad \text{……} \quad (12)$$

Edge normal

$$n1 = \nabla(g*p)/\nabla(g*p)| \quad \text{……} \quad (13)$$

Edge strengths

$$Gn\ P = \frac{\partial}{\partial n}[g * p] \quad \text{……} \quad (14)$$

Maximal strengths:

$$0 = \frac{\partial}{\partial n} GnP = \frac{\partial}{\partial n^2}^2 [g * p] \quad \text{…...} \quad (15)$$

Fig. III.5.1 Edge Detection Using Canny Technique

III. 6. Binary morphology:

Mathematical morphology is a new method applied in image processing. The basic idea is to measure and extract the corresponding shape from image with structural elements having stated form. So that the image processing and analyzing can be completed.

IV. BINARY MORPHOLOGY TECHNIQUES

In this paper, a new morphological approach for noise removal cum edge detection is introduced for both binary and gray scale images. For detecting edges in an image efficiently, first the noise is to be removed. Noise inbinary images is of two colors, black and white. The noise in gray scale images manifests itself as lightelements on a dark background and as dark elements on the light region. Noise is removed using morphologicaloperations and further morphological operations are applied on this image to extract the edges.

Simulation results of Binary Morphology Operation:

Fig. IV.1 Original Image

Fig. IV.2 Gray scale image

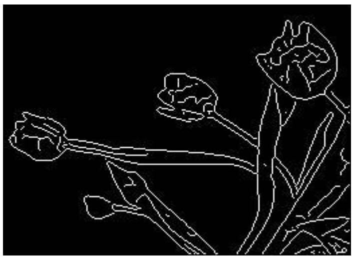

Fig. IV.3 Edge of an image using

Binary morphology

Using mathematical morphology to detect the edge is better than using differential treatment. Because it is not sensitive to noise, and the edge extracted is relatively smooth. Binary image is also known as black-and-white image. The object can be easily identified from the image background. So we adopt the combination of binary image and mathematical morphology to detect edge. It is called Binary morphology. Suppose that the region is shown in form of the set A. Its border is β (*A*). B is an appropriate structure element, and it is symmetrical around the origin.

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Firstly we corrupt A with Recorded as

$$A\Theta B = \{x \mid (B)_x \subseteq A\},$$

Where $(B)_x$ is a translation B along the vector. The interior of region is available with $A\Theta B$. And $A-(A\Theta B)$ is the borderline naturally. Then $\beta(A)$ is obtained. The equation of edge extraction can be said,

$$\beta(A) = A-(A\Theta B).$$

Structuring element is larger; the edge gained will be wider.

V. BORDERLINE CLOSED

Although image is de-noised before detecting edge, yet noises are still introduced when detecting edge. When noise exists, the borderline, which is obtained using derivative algorithm to detect image, usually produces the phenomenon of break. Under this situation, we need to connect the edge pixels. Thus, we will introduce a kind of method closing the borderline with the magnitude and direction of pixels gradient. The basis of connecting edge pixels is that they have definite similarity. Two aspects' one using gradient algorithm to process image. One is the magnitude of gradient; the other is direction of gradient. According to edge pixels gradient's similarity on these two aspects, the edge pixels can be connected. Specific speaking, if Pixel(s, t) is in neighbor region of the pixel (x, y) and their gradient magnitudes and gradient directions must satisfy two conditions (16) and (17) respectively, then the pixels in (s, t) and the pixels in (x, y) can be connected. The closed boundary will be obtained if all pixels are judged and connected

$$|\nabla f(x,y) - \nabla f(s,t)| \le T \ldots\ldots. (16)$$

$$|\varphi(x, y)-\varphi(x, t)| \le A \quad \ldots\ldots. (17)$$

Where T is magnitude threshold, A is angle threshold.

VI.CONCLUSION

These edge detection operators can have better edge effect under the circumstances of obvious edge and low noise. But the actual collected image has lots of noises. So many noises may be considered as edge to be detected. In order to solve the problem, wavelet transformation is used to demising the paper. Yet its effect will be better if those simulation images processed above are again processed through edge thinning and tracking. Although there are various edge detection methods in the domain of image edge detection, certain disadvantages always exist. For example, restraining noise and keeping detail can't achieve optimal effect simultaneously. Hence we will acquire satisfactory result if choosing suitable edge detection operator according to specific situation in practice.

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