A New Technique of Extraction of Edge Detection Using Digital Image Processing

Balaji S.C.K[1]

1, Asst Professor S.V.I.T

Abstract: *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 have some noise that may cause the of 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: *Image, Digital image, Edge, boundary, Edge detection, wavelet denoising, 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 [1]. 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. 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 denoised. In the process of denoising, 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 denoising method is the use of a low-pass or band-pass filter to denoise. 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 [2]. Because Wavelet denoising 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 denoising [3][4], etc
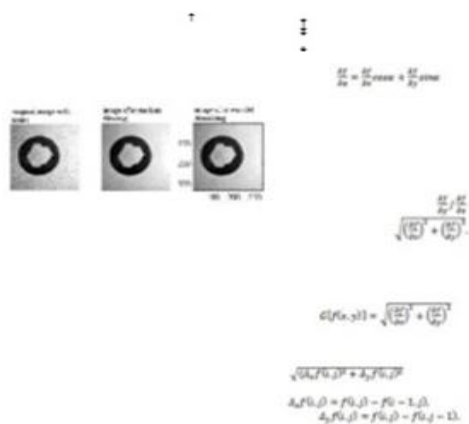
Image after denoising
fig1: Sketch of removing image noises with wavelet transformation

The basic process of denoising making use of wavelet transform is shown in Fig1, its main steps are [3][4] as follows:

1) Image is preprocessed (such as the gray- scaleadjustment, 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 denoising 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 denoising through Matlab is shown in Fig. 2.

Pretreating   Wavelet multiscale denoising

image with noiseSub-scale denoising
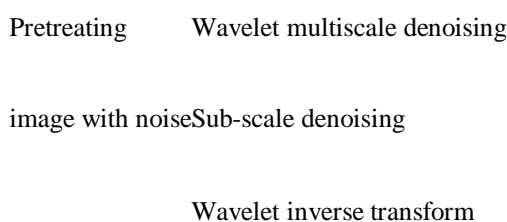
Wavelet inverse transform

Fig.2.Comparison of denoising methods

Comparing with the traditional matched filter, the high- frequency components of image may not be destroyed using wavelet transform to denoise. 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

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 the obtained edge points are connected to be a line.

A. 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 $f\partial/\partial x, f\partial/\partial y$. 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):

(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 []. The maximum of direction derivative is   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).

(2)

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

(3)
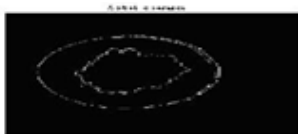
$$\Delta^2 f = \frac{\partial^2 f}{\partial x^2} \quad \frac{\partial^2 f}{\partial y^2}$$

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

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

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

$\sqrt{X^2 + Y^2}$

Differential operator mostly includes oberts operator and Sobel operator.

(1) Roberts operator:

Roberts operator is a kind of the most simple 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 operator is defined as:(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.

(5)

(6)

The template of the Roberts operator is shown in Fig. 3.

1 0   0 1

0 -1   1 0

Fig.3.Roberts Operator

(2) 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:

$$A0A1 \quad A2$$
$$A7f(x, y)A3$$
$$A6A5 \quad A4$$

We order that
X =(A0+2A1 +A2) -(A6+2A5+A4)
And Y = (A0+2A7 +A6) -(A2+2A3+A4) .

Then Prewitt operator is as follows:
G [f (i, j)] = (   ) (7)
G [f (i, j)] =/X/+/Y/   (8)

Prewitt operator is said in Fig.4 in the form of the template.

1-11   1 1 1

1-10   0 0 0

1-1-1
    -1-1-1

Fig.4.prewitt operator

Sobel operator can process those images with lots of noises and gray gradient well. We order that
X = (A0+2A1 +A2) - (A6+2A5+A4)
And Y = (A0+2A7 +A6)-(A2+2A3+A4).
Then Sobel operator is as follows:

G [f (i, j)] = (   )(9)
G [f (i, j)] =/X/+/Y/ (10)
The templates of sobel operator is shown in fig.5

1 2 1   10-1

0 0 0   20-2

-1-2- 1 10-1

Fig.5.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. 6 and Fig.7
Fig.6. Original image

$$x^2 + y^2 \quad \sigma^2$$

$$\nabla \quad \nabla$$

$$n \quad \frac{\partial}{\partial n}[g * p]$$

$$\frac{\partial}{\partial n}GnP = \frac{\partial}{\partial n^2}^2 \quad * p]$$

$$\Delta^2 f = \frac{\partial^2 f}{\partial x^2} \quad \frac{\partial^2 f}{\partial y^2}$$
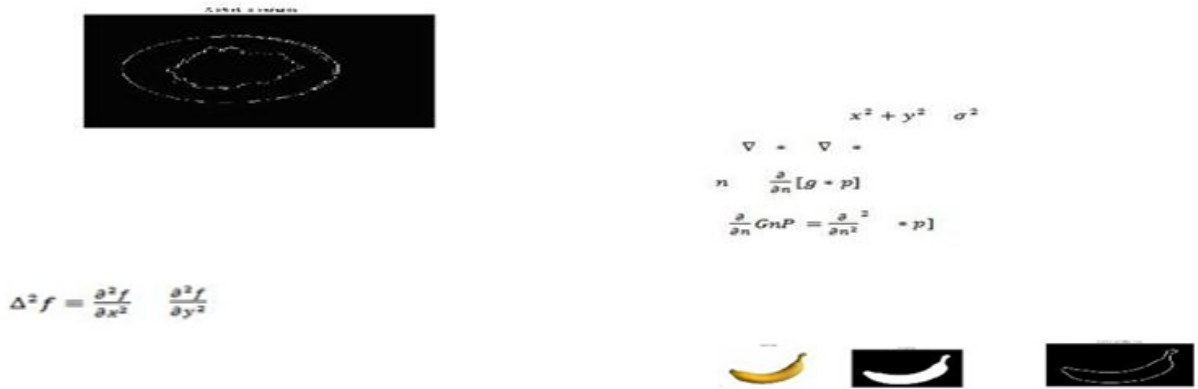

Fig. 7 the edge detection drawing of Sobel operator

From the simulation drawing Fig. 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.

B. 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) :

$$+(11)$$

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. 8

-1- 1-1 0 - 10

-18 -1
 -14 -1

-1-1 -1
 0 -1 -1

Fig. 8 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.

C. 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:

$$G(x, y) = \exp [-(\quad)/2](12)$$

Edge normal

$$n1 = \quad (g \; p)/| \; (gp)| \quad (13)$$

Edge strengths

$$G \quad P = \quad 14)$$

Maximal strengths:

$$0 = \quad [g \quad (15)$$

D. 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 [2].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. Firstly we corrupt A with Recorded as
AΘB ={x|(B)x⊆A},
Where (B)x is a translation B along the vector. The interior of region is available with AΘB. And A− (AΘB) is the borderline naturally. Then β (A) is obtained. The equation of edge extraction can be said,
β (A) = A− (AΘB) .
Structuring element is larger, the edge gained will be wider.

E. Simulative results analysis

In order to know about the advantages and disadvantages of these edge detection operators, we detect edge using these different operators respectively. The simulation results are shown in Fig. 9 and Fig. 10.
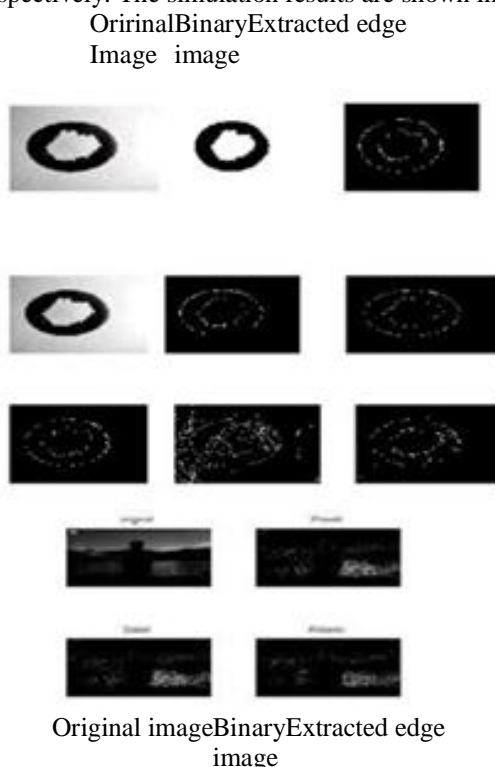
OririnalBinaryExtracted edge
Image image

Original imageBinaryExtracted edge
image
Fig.9.Detecting edge with binary morplology

OriginalRoberts operatorsobel operator
Image
prewitt operator canny operatorlog operator

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

$$|\nabla f(x,y) - \nabla f(s,t)| \leq T \qquad (16)$$

φ(x,y)-φ(x,t)|≤A(17)

Where T is magnitude threshold, A is angle threshold.