Image Segmentation Based on Sobel Edge Detection

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Keywords: MM-sobel, edge detection, mathematical morphology, image segmentation

Abstract. This paper aiming at the digital image processing, the system research to add salt and pepper noise, digital morphological preprocessing, image filtering noise reduction based on the MM-sobel edge detection and region growing for edge detection. System in this paper, the related knowledge, and application in various fields and studied and fully unifies in together, the four finished a pair of gray image edge detection is relatively complete algorithm, through the simulation experiment shows that the algorithm for edge detection effect is remarkable, in the case of almost can keep more edge details.

Research overview

The edge of the image is the most important visual information in an image. Image edge detection is the base of image analysis, image processing, computer vision, pattern recognition and human visual [1]. The ultimate goal is image segmentation; the largest premise is image edge detection. Image edge extraction plays an important role in image processing and machine vision. Proper image detection method is always the research hotspots in digital image processing, there are many methods to achieve edge detection, we expect to find an accurate positioning, strong anti-noise, not false, not missing detection algorithm [2]. The edge is an important feature of an image. Typically, when we take the digital image as input, the image edge is that the gray value of the image is changing radically and discontinuous, in mathematics the point is known as the break point of signal or singular point.

Sobel operator

The sobel operator is a method which use the mean of up and down, left and right adjoining pixels, and get the extremum at the edge. Because of the weighted mean, the operator can not only get the edge information, but also has the ability of anti-noise, it's one of the normal edge detection operators [3]. The S_x and S_y of Sobel operator can be calculated by convolution template.

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

(a) horizontal direction

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

(b) vertical direction

Figure 2.1 Sobel operator template

According to the detecting information, the image can be seen as a curved surface, edge is where changes most. The edge information contains two aspects: one is the direction of the edge, isolated edge is with no significance, the key is to stitch the corresponding edge into edge line. Another one is the certain location, just like the coordinates of pixels [4]. According to the knowledge of differential, we can judge the position information on the surface by using the derivative. The edge detection based on first order differential operator takes image as surface, then applies gradient operator on image *f(x,y)*, at last form the vector field.

$$\nabla f(x,y)=\left(\frac{\partial f}{\partial x},\frac{\partial f}{\partial y}\right) \tag{2.1}$$

The vector field provides two aspects information: one is the all the local gradient strength.

$$\|\nabla f(x,y)\|=\sqrt{\left((\frac{\partial f}{\partial x})^2+(\frac{\partial f}{\partial y})^2\right)} \tag{2.2}$$

Another is the direction of the local gradient.

$$\angle\nabla f(x,y)=\arctan\left(\frac{\partial f}{\partial x}/\frac{\partial f}{\partial y}\right) \tag{2.3}$$

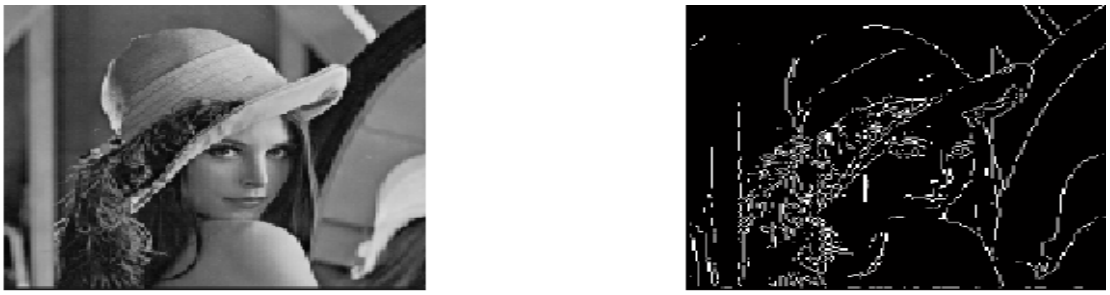
In the specific experimental scheme of edge detection, people often take care of how to find out ||f(x,y)||, thst is how to get the direction information. As for differential operator, we usually use difference or related technology to discrete, finally evolved into template operation form; it's very easy [5]. The general type of using Sobel operator to calculate ||f(x,y)|| is:

$$|T_1 f(i,j)|=\sqrt{\left(|S_x|^2+|S_y|^2\right)}$$

S_x and S_y are as follows:

$$S_x = f(i+1,j+1)+2f(i+1,j)+f(i+1,j-1)-f(i-1,j+1)-2f(i-1,j)-f(i-1,j-1) \tag{2.4}$$

$$S_y = f(i+1,j+1)+2f(i,j+1)+f(i-1,j+1)-f(i-1,j-1)-2f(i,j-1)-f(i+1,j-1) \tag{2.5}$$



（a） （b）

Figure 2.2 (a) the original image (b)detected image by Sobel

By comparing figure 2.2, Sobel operator increase the weight coefficient of the center pixel in the template floor, therefore, it can detect the edge with no great gradient mutation.

Experiments shows: the traditional Sobel operator constituted by the theory feature that gray function can get the part maximum at the edge can achieve edge detection by using the sum of gray weighted difference comes from four directions's adjoining pixels. This kind of algorithm is easy to realize, and it can provide accurate edge direction information. It has a smoothing effect on noise and has the ability of anti-noise, especially when used in large imgage. However, as we see the result of simulation, there exists some false edge, the precision of image edge location is low. When used in large image, the amount of calculation will be large, and the edge is not clear; the amount of calculation will increase as direction increases.

Region growing

The main idea of region growing is that gather the pixels of similar property together. First find a seed pixel as the beginning in every region that needs to be cut apart, and then put the adjoining pixels which has the similar property in the same region. The new pixel will be a new seed, and it grows to all around until no pixels satisfy the principle, then the region is grown.

Now we give an example on how the region grows. The given matrix A:

$$\begin{vmatrix} 1 & 0 & 4 & 7 & 5 \\ 1 & 0 & 4 & 7 & 7 \\ 0 & 1 & 5 & 5 & 5 \\ 2 & 0 & 5 & 6 & 5 \\ 2 & 2 & 5 & 6 & 4 \end{vmatrix}$$

In the matrix, 5 is the first seed. We calculate the difference of 5 with the pixels all around, if the difference is small than a threshold T, we take this pixel as a new seed, and then repeat the calculation to all the seeds. If we set the threshold as T = 1, then the result of region growing is:

$$\begin{vmatrix} 1 & 0 & 5 & 7 & 5 \\ 1 & 0 & 5 & 7 & 7 \\ 0 & 1 & 5 & 5 & 5 \\ 2 & 0 & 5 & 5 & 5 \\ 2 & 2 & 5 & 5 & 5 \end{vmatrix}$$

As we can see, the gray value 4,5,6 which are around the first seed gathered into the growing region, the gray value 0,1,2,7 which are on boundary have become boundary. Although the 5 on top right corner can become a seed, but there are not any one seed around it, so it's out of growing region. If we set the threshold as T = 3, the new region growing result is:

$$\begin{vmatrix} 5 & 5 & 5 & 5 & 5 \\ 5 & 5 & 5 & 5 & 5 \\ 5 & 5 & 5 & 5 & 5 \\ 5 & 5 & 5 & 5 & 5 \\ 5 & 5 & 5 & 5 & 5 \end{vmatrix}$$

As we can see, the whole matrix is in the region. So the threshold is very important.

In real application of region growing, there exists three problems to be solved:

a. Select or determine a set of seed pixels which can represents the desired area correctly.
b. Identify the guideline which can gather the adjacent pixels together when grows.
c. Confirm the rules that stop the growing process.

The typical method is shrinking from large to small by iteration, it's useful to both 2D and 3D images. Usually we choose the lightest pixel as seed, or with the help of calculation on every pixel, if the result of calculation shows clustering, we choose the center pixel of the clustering as seed. In the example above, analyzing the histogram we can get that gray value which is 1 and 5 is in the center. So we can choose the clustering center pixel as seed.

How to choose rules of growing not only depends on the problem itself, but also relate to the type of data, such as colorful image and gray image. Usually, the growing will stop when no pixel satisfies the growing rules. In order to make the region growing strong, we always consider some rules related to size, shape and the global properties of the target.

The key of region growing is choosing the proper rules. There are two kinds of growth standards and methods: based on region gray difference, based on the statistical properties of gray distribution. The results are as follow:

grey-scale map binaryzation image result of reigon growing

Because the details of lena is strong (such as the hair), the calculation through region growing may fail to link all the region together, so we calculated it's mean value for three times. After that the smaller region can combine better.

The results of experiments

（a）original image （b）noise （d）3*3 median filtering（d）binaryzation

（e）sobel edge detection（f）MM-sobel edge detection（g) image segmentation

Conclusion

This paper mainly aimed at digital image processing, research on filtering image with salt and pepper noise, edge detection based MM-sobel and edge extraction by using region growing. Our experiment achieve a complete algorithm on edge detection with a gray level image: first, based on filter model with salt and pepper noise; then the edge detection based on sobel operator; finally image segment algorithm based on region growing. Through the research, we finally choose edge detection based on MM-sobel, it has clear processing result and outline.

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