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Neuronal Edge Detection with Median Filtering and Gradient Sharpening

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Abstract

Edge detection is the process of finding out edge of the objects from images. It is the fundamental of pattern recognition in digital image processing field, and it plays an important role in the application of computer vision. A method for edge detection based on median filtering and gradient sharpening was proposed in this paper. At first median filtering was used to remove the noise because it can protect the edge of the image at the same

1. Introduction

Edge detection is important issue in digital image process field; it is the base of further research of pattern recognition and plays an important role in the application of computer vision. Although a number of algorithms have been proposed [1 3], there is no general algorithm. Edge detection is still one of the challenges in digital image process field.

Edge represents the discontinuity of image local feature and locates between object and background, object and object, as well as area and area. It contains lots of information about image for analysis and research. Median filter, low pass filter, smooth, mean filter, and band pass filter are the common denosing methods [4 5]. We have examined several filtering methods and find median filtering is the best one for our image. We also have examined method [3 8], local iterative threshold method in binarization and find the threshold with value 130 is the best global threshold.

2. Median Filter

The input image contains noise which could be detected as the edge, thus the denosing method is required. We use median filter, it is a non liner signal process based on the order statistical theory. Median filter has a good effect on removing the salt and pepper noise [9 10]. , it also has some ability to preserve marginal information, so it is widely used in edge extraction in digital image.

Median filter could smooth the image and compact the strength range of pixels especially background pixels [11 14]. Median filter select a window W which contains odd pixels and find the median of them in gray value, the window centers on pixel (x, y) , median filter replace the gray value of pixel (x, y) with median. The gray value of center $f(x, y)$ turns to $g(x, y)$ after filtering. The filter is as equation 1:

$$g(x, y) = \text{median}\{f(x-k, y-l), k, l \in W\} \quad (1)$$

where W is the size of window.

3. Gradient Sharpening

Filter could remove the noise, but at the same time remove the edge. For preventing losing of edge and improving the effect of edge detection, we sharpen the image. There are two method for image sharpening: differential method and high pass filter, the former is conducted in spatial domain and process the gray value of pixels directly ,it contains first order difference and first difference, the latter is conducted in frequency domain and make the edge clear by suppress low frequency component and intensifying high frequency component. In this paper, we use the gradient sharpening based on first order difference.

Gradient describes the transformation of image. It is a vector. The magnitude of the vector represent the transformation rate of the image, the direction of the vector denotes the direction which has the highest transformation rate. The edge of image has the highest variance rate of gray value, thus gradient could be used to sharp the image.

3.1. Gradient calculation

We use $f(x, y)$ to denote an image, the gradient of (x, y) could be calculated by:

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

Direction is:

$$\phi(x, y) = \arctan \frac{\frac{\partial f}{\partial y}}{\frac{\partial f}{\partial x}} \quad (3)$$

In application, horizontal and vertical first difference could be used to approximately substitute first order difference:

$$\frac{\partial f}{\partial x} = f(i, j+1) - f(i, j) \quad (4)$$

$$\frac{\partial f}{\partial y} = f(i, j) - f(i+1, j) \quad (5)$$

For simplification, the sum of the absolute value of two components could be used to approximate the square root of the quadratic sum of them.

$$G(i, j) = \sqrt{\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2} \approx \left|\frac{\partial f}{\partial x}\right| + \left|\frac{\partial f}{\partial y}\right| \quad (6)$$

The last row and column are hard to calculate, they could be approximately substituted by their previous row or column.

3.2. Sharpen

Calculate the gradient for each pixel, if the value is greater than T and less than 255, the pixel is considered as edge and set the gradient value as its gray value, if the value is less than T , keep its gray value unchanged, if the value is greater than 255, set its gray value to 255. The formulation as follow:

$$g(i, j) = \begin{cases} G(i, j), T \leq G(i, j) < 255 \\ f(i, j), G(i, j) < T \\ 255, G(i, j) > 255 \end{cases} \quad (7)$$

where $f(i, j)$ is the gray value of input image, and $g(i, j)$ is the gray value after gradient sharpening.

4. Binarization

For obtaining the initial edge and highlight the profile, we need binarization. Binarization is the process which divides the pixels into two groups according to threshold T and set the value of the two groups to 255 and 0 respectively. In this paper, we choose 127 as the value of threshold, the formulation as follow:

$$g(x, y) = \begin{cases} 0, f(x, y) < T \\ 255, f(x, y) \geq T \end{cases} \quad (8)$$

where $f(x, y)$ is the input image, $g(x, y)$ is the binary image, and T is the threshold.

5. Connected Component Labeling Method

Suppose that the original image has h rows and w columns, the black patch elimination algorithm for connected component labeling method is as follows:

Step1: Conduct color inverse on image;

Step2: Obtain L and num;

Step3: for $i=1$: num do

Find the connected area with label i by find function.

Find the extremum with coordinate x or y and denoted as: $\min\_x$, $\max\_x$, $\min\_y$, $\max\_y$;

if $\min\_x > 1$ and $\max\_x < h$ and $\min\_y > 1$ and $\max\_y < w$ then

set the pixel value of (x, y) to 0.

Step4: Conduct color inverse on image again to obtain the final image.

Color inverse is the crucial step in connected component labeling method, because the edge locates in black area whose pixel value is 0, by color inverse, the value turns to 255 to satisfy the function. By connected component labeling, the black patches which in closed area and have no link to edge could be removed, but the abrupt burr on the edge cannot be removed.

6. Experimental Result

The results of the structure extraction are showed as follows:

Fig.1. (a) original image (b) experiment results (c) gold standard

Fig.2. (a) original image (b) experiment results (c) gold standard

7. Pixel Error

Pixel error counts the number of different value between pixel of edge L and corresponding pixel of edge L^* , it could be represented by the square of Euclidean distance, it also equals in Hamming distance due to the binary image, thus, if the pixel values of the image are 0 and 1, the sum of the absolute value of corresponding pixel gray value difference could be obtained, the sum is the number of the corresponding pixel which has different value. If the total number of the pixels in the image is N

and the number of pixels with different value between manual work image and machine work image, then the pixel error could be represented as:

$$e_p = \frac{n}{N} \quad (9)$$

If the pixel values of the binary image are 0 and 1, $H(i, j)$ and $R(i, j)$ denotes the pixel value of (i, j) from image processed by manual work and our algorithm respectively, then error e_p could be formulated as:

$$e_p = \frac{\sum_{i,j} |H(i, j) - R(i, j)|}{N} \quad (10)$$

Calculation suggests that the pixel errors of Fig.1(b) and Fig.2(b) which obtained from our algorithm are 14.3% and 14.1%.

8. Discussion and Conclusion

From the naked eye observation and error analysis, our algorithm extracts the edge of Fig.1(a) and Fig.2(a) well. It suggests that our algorithm apply to extracting the noisy edge of grayscale image; there are some breakage and black patches on the edge in Fig.1(b) and Fig.2(b). However, our algorithm cannot extract details accurately. Our further research will involve machine learning to the improvement based on error analysis.

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