Image Contour Extraction and Analysis Based on Edge Detection Algorithm

Qinghong Shao, Kangping Chen
Jiangxi Agricultural University, Nanchang 330045, China.

Abstract:With the development of science and technology, the requirements for the measurement accuracy of various workpiece parts are getting higher and higher. In this article, we combine the traditional edgedetection algorithm and subpixel edge detection algorithm to analyze the three workpiece parts pictures extracts the edge contour, and combines the sobel and canny algorithm to detect the edge contour. For the third photo taken under complex light, we constructed different series filters and parallel filters for filtering and denoising, and then extracted and analyzed the slices. The results show that our method achieves good results in contour extraction.
Keywords: Sobel; Canny; Sub-Pixel; Ramer-Douglas-Peucker

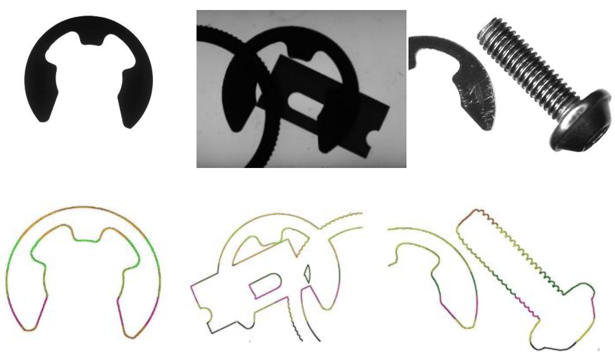

Fig1：The three pictures below are processed

2. Algorithms of Image Edge Analysis and Detection

2.1.1 Sobel edge detection operator

The gradient value at a certain pixel in the image is proportional to the difference in gray value between adjacent pixels around that point. Therefore, the larger the gradient value of the pixel, the greater the gray change in the corresponding adjacent area. Fast, such as the edge of the image. Conversely, if the gradient value of the pixel is smaller, the gray scale change of the adjacent area is also slower . So by solving the first derivative of the image, we can know the gradient value of the image, and further we can know the edge of the image. Based on the above theory, the Sobel edge detection operator calculates the gray value of adjacent pixels in the upper, lower, left and right directions of each pixel in the image, and obtains their weighted difference. The closer to the center pixel, the greater the weight. Then differentiate and gradient them.

$$\frac{\partial I}{\partial x}=[f(x-1,y+1)+2f(x,y+1),f(x+1,y+1)]-[f(x-1,y-1)+2f(x,y-1)+f(x+1,y-1)]$$

$$\frac{\partial I}{\partial y}=[f(x+1,y-1)+2f(x,y-1),f(x-1,y-1)]-[f(x+1,y+1)+2f(x,y+1)+f(x-1,y+1)]$$

The convolution kernel used by the W. Sobel operator is a 3*3 matrix, usually a horizontal template: $\begin{bmatrix}-1 & 0 & 1\\ -2 & 0 & 2\\ -1 & 0 & 1\end{bmatrix}$, Vertical template: $\begin{bmatrix}-1 & -2 & -1\\ 0 & 0 & 0\\ 1 & 2 & 1\end{bmatrix}$.

Because the Sobel operator weights the influence of the pixel position, the result is relatively better. The other kind of Sobel operator, which is composed of two templates,is the isotropic operator, and the one with a horizontal edge is:

$\begin{bmatrix}-1 & 0 & 1\\ -\sqrt{2} & 0 & -\sqrt{2}\\ -1 & 0 & 1\end{bmatrix}$, And the other vertical edge is $\begin{bmatrix}-1 & -\sqrt{2} & -1\\ 0 & 0 & 0\\ 1 & \sqrt{2} & 1\end{bmatrix}$.

Compared with general operators, the isotropic Sobel operator has more correct position weighting coefficients, so the results are the same when detecting edges in different directions.

2.1.2 Canny

The Canny edge detector is the first derivative of the Gaussian function. Generally, good edge detection includes the following three features:

a. Low misjudgment rate, that is, as far as possible, the edge points are mistaken for non-edge points.

b. High positioning accuracy, that is, accurately position the edge point on the pixel point with the largest gray-scale change.

c. Suppress false edges. Starting from these three indicators, Canny derives the best edge detection operator-Canny edge detection operator.

First set a two-dimensional Gaussian function:

$$G(x,y)=\frac{1}{2\pi\sigma}\exp(\frac{-(x^2+y^2)}{2\sigma^2})$$

Then find the first-order directional derivative of the Gaussian function G (x,y) in a certain direction as:

$$\nabla G(x,y)=\begin{pmatrix}\frac{\partial G}{\partial x}\\ \frac{\partial G}{\partial y}\end{pmatrix}$$

The Canny edge detection operator is based on two-dimensional:

$$\nabla G(x,y) f(x,y)$$

The edge strength is based on the edge strength, and the edge strength is determined by

$$n = \frac{\nabla G(x,y) f(x,y)}{\partial x}$$

The basic idea of this operator is: first select a certain Gaussian filter to smoothly filter the processed image to suppress image noise; then use a technique called "non- extreme suppression" to control the gradient of the smoothed image The amplitude matrix is refined to find possible edge points in the image; finally, double thresholds are used to detect the edge points of the image to remove false edges. In other words, the edge point detected by the Canny operator is the turning point of the smooth image processed by the Gaussian function.

The Canny edge detection method also uses the Laplacian operator. The difference between this method and other edge detection methods is that it uses two different thresholds to detect strong and weak edges respectively, and only when the weak edge is connected to the strong edge Only when the weak edges are included in the output image, this method is easy to detect the real weak edges, and has a strong ability to suppress noise.

2.1.3 Prewitt edge detection operatorz

The Prewitt operator is similar to the Sobel operator, and also uses a local average combined with directional difference. The difference between them is that the convolu- tion templates used are different. Prewitt uses average weighting, which is the average weighting of the affected pixels around the center pixel, while Sobel determines the different weights according to the magnitude of the mutual influence of adjacent pixels. Value, that is, the closer the pixel is to the center, the greater the influence, and the greater the same weight.

The gradients of the Prewitt operator in the X and Y directions are

$$\frac{\partial I}{\partial x} = [f(x-1,y+1) + 2f(x,y+1), f(x+1,y+1)] - [f(x-1,y-1) + 2f(x,y-1) + f(x+1,y-1)]$$

$$\frac{\partial I}{\partial y} = [f(x+1,y-1) + 2f(x,y-1), f(x-1,y-1)] - [f(x+1,y+1) + 2f(x,y+1) + f(x-1,y+1)]$$

The corresponding convolution template is $G(x) = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$,and its extended tem-plate is $G(y) = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix}$.

2.1.4 Laplacian

Pull operator is a kind of second-order differential operator, and it is isotropic. Due to the first derivative of the edge point position It often reaches a maximum at the edge point, and the second derivative presents a zero crossing at the edge point position. Therefore, the zero-crossing point of the second derivative is also a method to detect the edge, but it is suitable for considering only the edge position without considering its neighborhood The case of pixel grayscale difference. And the pull operator responds more strongly to individual pixels than to edges or lines, so it is only suitable for images that do not contain noise. For images that contain noise, a low-pass filter must be used first when detecting. Filter it.

2.1.6 Edge Burrow and Shadow Treatment

Based on the improved morphological gradient and Zernike moment sub-pixel edge detection method, it has good anti-noise performance and sub-pixel precise positioning ability, and its calculation is relatively small.

For edge burrs and shadows existing in the edges of the image, median filtering and dilation methods can be used to deal with them. The specific steps are

(1) Obtain the original grayscale image, and obtain the pixel-level rough edges of the original grayscale image.

(2) Index to the edge point of the pixel-level coarse edge, and use the interpolation method to expand the edge along the gradient direction.

(3) Perform sub-pixel detection on the expanded edge point to obtain the sub-pixel po- sition of the edge.

(4) Using the Canny edge detection method to obtain the pixel-level rough edge of the original grayscale image, the pixel-level rough edge is a pixel-level single-edge binary image detected by Canny.

(5) Use interpolation to extend the edge along the gradient direction, including positio-ing to the edge point NxN pixel neighborhood, where N is an integer greater than or equal to 1, calculate the gradient direction of the center edge point of the pixel neighborhood, and use a double line The linear interpolation method interpolates the pixel neighbor- hood along the gradient direction of the edge point. The gradient direction of the edge point is the direction of the gradient detected by the Soble operator. The bidirectional interpolation direction is the sum of the horizontal direction and the vertical direction. The ratio of the sagittal shape in the horizontal direction and the sagittal shape in the vertical direction is the tangent value of the gradient direction of the edge point.

(6) Median filtering and dilation for the expanded edge to eliminate burrs.The grayscale image can be expanded and then corroded after expansion. The expanded and then corroded image is subtracted from the original grayscale image and then reversed .

(7) Perform sub-pixel detection on the extended edge point to obtain the sub-pixel position of the edge, including using the Zernike polynomial template to calculate the position parameter of the extended edge point, and recover the edge parameter scale. The Zernike polynomial template is an image convolution template for calculating Zernike moments of an image, and the edge parameter scale restoration is a parameter scale restoration based on the template effect calculated using the Zernike unit circle tem-plate.

(8) After obtaining the position parameters of the edge points, we can output the posi-tions of the points in order, and use opencv to calculate the number and length of the edge contours.

Space is limited, the detailed image processing process in the paper can be foundinmy blog： https://blog.csdn.net/qq_40514113?spm=1011.2415.3001.534.

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