

Spline interpolation sub pixel edge detection method based on improved morphological gradient

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Abstract: In order to improve the accuracy of image edge detection. A spline interpolation sub pixel edge detection method based on improved morphological gradient is proposed in the thesis. Firstly, using improved morphological gradient filter operator for image coarse positioning; Then, the cubic spline interpolation method is carried out for pixel-level edge of the image interpolation so that the image edge locates in sub-pixel level. Have a simulation experiment to improved methods by Matlab, results show that the improved method can accurately detect the edge of the image, edge detection is fine, the precision of positioning is high and the result of detection is good.

Regard the image as a carrier of detection and transmission of information, the purpose is to obtain useful information from the image, while the measured object properly is reflected and addressed^[1]. In this process. It is important to extract the edge of the image accurately, because the edge of the image can provide useful information and many important parameters then from it, we obtain the target characteristics. The edge is the most basic features of the image and it is a description of the image, which contains useful information for identifying the target image. Therefore, the edge detection plays an important role in the visual inspection system. With the need of detection accuracy is improving, pixel-level accuracy has been unable to meet the actual demand. Therefore, you need to have a more accurate edge detection algorithm, that is, sub-pixel edge detection algorithm. Application of sub-pixel edge detection^[3] technology is an important means to achieve high-precision measurements. The method is simple, effective, and low cost. Therefore, based on Sub - pixel edge detection technique is the key technologies and research focus in the visual inspection system, the study has an important academic significance and applied value.

1 Improved gradient morphology

Many common pixel-level edge detection operators detect the edges in the image at the same time strengthen the image noise. This precision will affect the edge detection. However, morphological edge detector is applied to the concept of morphology. While it is also sensitive to noise, but it does not enhance or amplify noise. The definition of a single scale morphological gradient:

$$\text{Grad}[f(x)] = (f \oplus b) - (f \ominus b) \quad (1)$$

f -----Original image; b -----Structural elements

As the performance of single-scale morphological gradient is greatly influenced by structural elements^[2]. The larger or smaller structural elements will give a serious impact on test results. So the single-scale morphological gradient is improved. The improved morphological gradient operator is defined as:

$$IGrad[f] = (f \circ b) \oplus b - (f \bullet b) \ominus b \quad (2)$$

Since the width of the random noise may be less than the width of the structural elements, so that the image will be mixed with the random noise in the processed. Therefore, it is difficult to achieve optimum detection results by using a single structure element edge detection. We select two structural elements of size 5×5 , one of which is a cross-shaped and the other is a cruciform-shaped. And make it symmetrical about the origin and complementary. When performing calculations, using a weighted combination of these two morphological gradient. The improved morphological gradient filter operator is:

$$IGrad[f] = c_1 IGrad1[f] + c_2 IGrad2[f] \quad (3)$$

c_1, c_2 Weight coefficient; $IGrad1, IGrad2$ Two structural elements of different shapes corresponding improvement morphological gradient

Due to the improved utilization of morphological gradient filter operator of two different structural elements of edge detection and the edge of detection is fine, while suppressing random noise. Therefore, the improved morphological gradient filter operator has a higher the edge of detection accuracy and strong anti-noise capability. In addition, the improved morphological gradient filter operator has a prominent advantage: When using linear filtering method for smoothing the noise it will not cause the edge of the target image becomes blurred while this method is easy to parallel computing and the processing time is shorter.

2 Sub-pixel edge detection^[3] method of cubic spline interpolation^[4]

Currently, the main method of interpolation is double interpolation methods, the closest interpolation, cubic spline interpolation method. Linear interpolation method using four temporary gray point in two directions to make the linear interpolation, which overcome the disadvantage of the gradation discontinuity. But it has a low-pass filtering property that allows high-frequency component to be damaged and the image contours are fuzzy. While in theory, the Sinc function can be completely rebuilt the continuous image, but the calculated amount of the function is too large and the real time are too poor. So an improved method of this paper is to use the cubic spline interpolation function for the interpolation image edge processing. In fact, in the one-dimensional space, if the quadratic function $f(x, y)$ is successive and differentiable in the interval $[a, b]$. Then the cubic spline function of this quadratic function must be successive and differentiable. Definition of the cubic spline interpolation function is:

Assuming that the interpolation nodes $a = x_1 < x_2 < \dots < x_n = b$ in the interval $[a, b]$ and corresponding to the function value are y_1, y_2, \dots, y_n . If the function $S(x)$ satisfies $S(x_j) = y_j (j=1, 2, \dots, n)$, then the function $S(x)$ is not higher than the cubic polynomial in the interval $[x_j, x_{j+1}] (j = 1, 2, \dots, n-1)$. When the function $S(x)$ has a second-order continuous derivative in the interval $[a, b]$, then called the function $S(x)$ is a cubic spline interpolation function.

The expression of Cubic Spline Interpolation function used in this paper are:

$$S(w) = \begin{cases} 1 - 2|w|^2 + |w|^3 & |w| < 1 \\ -8|w| + 5|w|^2 + |w|^3 & 1 \leq |w| \leq 2 \\ 0 & |w| \geq 2 \end{cases} \quad (4)$$

w.....Spline node

In this paper, all are two-dimensional images of the edge of detection processing. The spline interpolation of two-dimensional is shown schematically in Figure 1.

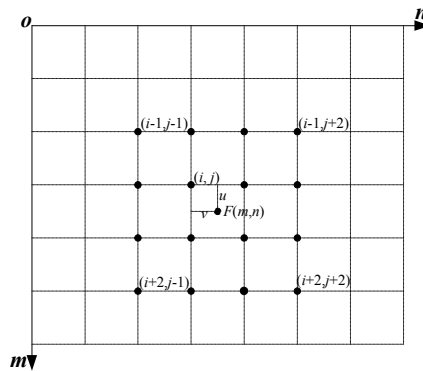


Fig.1 Two-dimensional spline interpolation Figure

This implementation process of the improved algorithm is as follows:

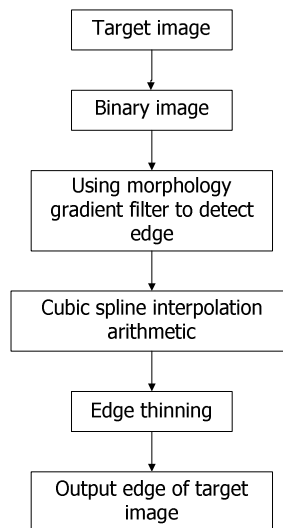
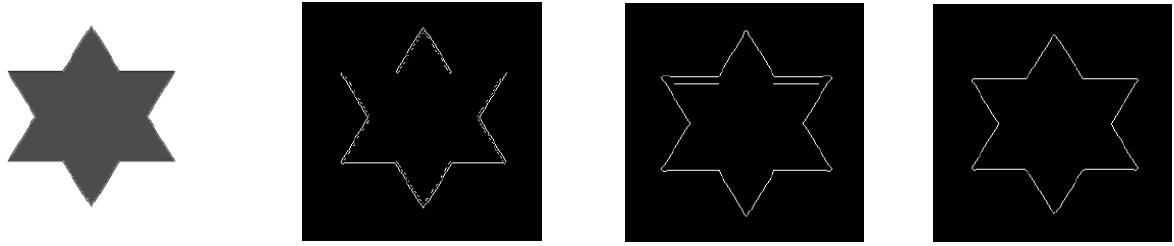


Fig. 2 The algorithm flow chart

3 Analysis of experimental data and results

To verify the superiority and effectiveness of the improved algorithm, compares the detection time with the detection effect of the Soble operator^[5], Log operator and improved algorithm.



(a)Original hexagonal pattern (b) sobel operator (c)log operator (d)Improved Algorithm

Fig.3 The edge detection results of hexagon

We can see from the comparison chart 3, sobel edge detection operator is more obscure and not smooth,log operator detect the edge contains a lot of false edges,improved algorithm for detecting that the image edge is smaller, positioning accuracy is higher and detection is better.

Table 1:Comparison with the classic edge detection algorithm detection time

Algorithm name	Sobel	Log	Improved Algorithm
detection time (s)	0.561	1.017	1.296

Table 2:Comparison with sub-pixel edge detection algorithm detection time

Algorithm name	Spatial Moment	Gray Moment	Zernike Moment	Digital Correlation	Improved Algorithm
detection time (s)	1.633	1.597	1.472	1.538	1.296

We also see from the table 1, although the pixel edge detection method of classic is faster,but the detection effect of the improved method is better than the classic method.As it is seen from table 2, the detection time of improved methods should be shorter than several other commonly used sub-pixel edge detection methods and the detect effect is faster.It can meet more requirements of real-time.

4 Conclusion:

Spline interpolation sub-pixel edge detection method based on improved morphological gradient can accurately detect the image edge,edge detection is smaller,positioning accuracy is higher.Detection effect is significantly better than the traditional edge detection method.

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