A study on contour extraction method in computer vision measurement technology

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Abstract

Image segmentation and border extracting technology play an important role in the computer vision measurement system Aiming at the shortcomings of traditional edge detection methods, considering the features of computer vision measurement, a practical contour extraction method is introduced. In the method, image segmentation is based on the gray threshold method, the mathematical morphology method is adopted to remedy the defects of binary image, the contour of image is stored into chain—code through contour tracking algorithm. Using this method, the one—pixel—wide border of image can be easily extracted. The principles and algorithms of key technologies of the method are described. The experiments show that the features of the method such as denoise and precision are better than that of the traditional edge detection methods. It can be applied to practical engineering measurement system.

Keywords: metrology; contour extraction; image segmentation; computer vision; mathematical morphology; gray threshold method.

1 Introduction

Computer vision measurement technology is based on optics, and mixed together with optoelectronics, computer technology, image processing technology and such many integrated technology of modern science. It collect the geometrical characteristic parameters through processing the object image, the extraction of target object contour has become the main factors influencing the accuracy of measurement. Therefore, in the measurement system based on computer vision, in order to ensure the accuracy of measurement it is very important to select appropriate contour extraction method. Edge contour extraction is the basic method of test; means with the aid of the airspace differential operator, completed through image convolution is template. Classical edge detection method are local operator method, such as gradient operator, Sobel operator, Roberts operator, Canny operator etc. the method has the advantages of simple implementation, fast computing speed, but has the following disadvantages: the detected edge can't guarantee the wide of single pixel, which tends to appear the edge of isolated or just the small section continuous. Therefore, it need for refinement processing, at the same time try to connect the discontinuous edge pixels, so as to complete the contour extraction. Obviously, this process is too complicated, the accuracy of extracting contour cannot be guaranteed. In some cases, because of the influence of the noise, the image contour even can't be extracted. Aim at the problems existing in the method of traditional edge detection, combining with the characteristics of computer vision measurement technology, this paper proposes a practical method of contour extraction, that is using gray threshold method for image segmentation, and repair the defect of binary image with mathematical morphological method by chain code tracking storage contour information, realizing the image contour extraction with single pixel edge. Experimental results show that compared with the classical edge detection methods, this method is featured by strong anti-interference, high precision, etc. which can meet the practical need of engineering survey.

2 The principle of contour extraction

Obtain the object outline of target object from the image of object is called contour extraction; it is the key to ensure measurement accuracy. As to the characteristics that the images of computer vision measurement often contain only two targets(work piece) and the background area, this paper uses the gray threshold method for image segmentation; Uses nonlinear filtering properties of mathematical morphology to eliminate defects and noise in a binary image; Adopts the method of hollowed interior points to extract contour from binary images; Saves contour information by using the method of chain code tracking, to make the processing and measurement of outline more reliable and convenient. Its working process is shown in Figure 1, it at first filters out the noise in the image by image preprocessing, and then uses threshold method to carve up image to get the binary image, gets outline point through flaw repairing treatment and have image contour extraction (target outline), finally it stores the outline as chain code format through the contour tracking algorithm.

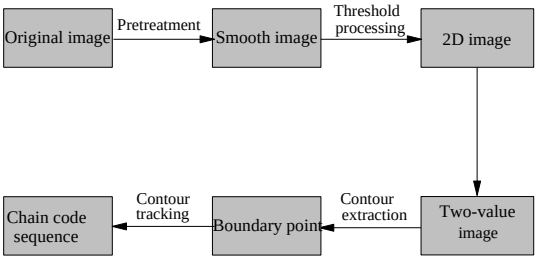


FIGURE 1 The progress of contour extraction based on gray threshold

3 Key technology

A. Image pre-treatment

Two dimension images generated by optical image system always contain noise, to promote the visual performance of computer, and increase the analysis and recognition capability of computer, the noise of original image should be wiped out. This treatment technology which extrudes useful information restrains useless information and improves images quality is called image pre-treatment.

The process of image re-treatment is the progress to carry on some change on input images, so as to get brilliant images. For example, noise should be wiped out, disturb should be sheltered and SNR be promoted on images containing noise; Grey level transformation this enhancement process should be taken to small CNT image; Carry on a variety of rehabilitation treatment as to degraded blurred images; Geometric correction this transform have to be taken on the distortion images. The purpose of the image pre-processed in the image measurement technology based on computer vision pre-processing is to improve the quality of the image, to make images easy to be disposed and measure. Image pre-processing methods which are often used mainly include: image smoothing, image sharpening, image edge enhancement these methods, etc.

B. Threshold segmentation

The images in computer vision measurement generally consist of target (work piece) and the background region, therefore, this article uses single threshold segmentation method for image segmentation. Its process includes two steps: one is to determine the threshold segmentation value, the second is to compare segmentation threshold with gray levels of pixels.

The basic principle of threshold segmentation is : if the gray section of image $f(x, y)$ is $[Z_{min}, Z_{max}]$, set a threshold value Z_t in the area, and $Z_{min} < Z_t < Z_{max}$, make the new grey values of all the image pixels zero of which the grey values are less than or equal to Z_t, and make the new grey values of image pixels one of which the grey values are greater than Z_t, that is to build up a output binary image $f_t(x, y)$ through the threshold segmentation:

$$f_t(x,y)=\begin{cases}1 & f(x,y)>Z_t\\ 0 & f(x,y)\le Z_t\end{cases}. \qquad (1)$$

Threshold segmentation aims to discard redundant information under the premise of keep the characteristics of the image as much as possible [2], therefore, the key problem in the single threshold value method is how to correctly determine the gray threshold Z_t, that is to confirm the abrupt change point of the grey value. In this paper, iterative method is used to determine the threshold Z_t its principle is based on the idea of approaching, according to the results of the gray histogram statistics to determine the initial threshold, using the threshold value to split image into the target and background, and take the average gray-value of them as a new threshold, it gets the threshold value through the loop iteration and stops until the threshold from twice circulation differ little, finally gets gray-level threshold Z_t. This method has the advantages of simple algorithm, easy to implement, the specific steps are as follows:

(1) Determine the maximum grey value Z_{max} and minimum gray value Z_{min} of image, make the initial value of threshold Z_t $(Z_{max} + Z_{min})/2$;
(2) Split the image into the target and background according to the threshold Z_t, determine the average grey value of the Z_O and Z_B respectively;
(3) Determine the new threshold $Z_{t+1} = (Z_O + Z_B)/2$;
(4) If $Z_t = Z_{t+1}$, and the income is the threshold value; Otherwise make $Z_t = Z_{t+1}$ turn to step (2) to continue iterative calculation.

C. Defect repair

The binary image obtained by threshold segmentation may exist defects such as break stitches, concave rag etc., if carry on the image contour extraction directly especially when there is noise existing in the image, the outline contains defects such as breakpoints, burrs etc. will be secured, which will come about with difficulties on further processing ion the outline, and even affect the measurement accuracy, therefore, measures must be taken to eliminate these defects. Mathematical morphology is a nonlinear filtering method, the expansion and erosion operation have intuitive geometric background, which can make the image thinning or thickening in a certain direction, the direction depends on the selected structure elements. On account of this feature, this paper uses the mathematical morphology method to repair the defects of binary images, to eliminate defects and noise in the images. Mathematical morphology use set to describe the binary image, with structural elements for morphological transformation. Among which, Morphological transformation includes four basic operations [3]: Dilation, Erosion, Open and Close.

Set A as the input binary image; adopt structural elements B to have morphological processing on image. A is expanded by B, can be expressed as $A \oplus B$, defined as:

$$A \oplus B = \{x \mid x = a + b, \text{ for some } a \in A \text{ and } b \in B\}, \qquad (2)$$

A is corroded by B, which can be expressed as $A \Theta B$, defined as:

$$A \Theta B = \{x \mid (x + b) \in A. \text{ for each } b \in B\}, \qquad (3)$$

A is opened operation by B, can be expressed as $A \circ B$, defined as:

$$A \circ B = (A \Theta B) \oplus B, \quad (4)$$

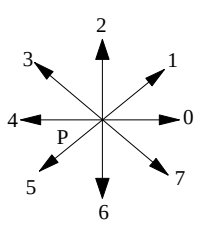
A is closed operation by B, which can be expressed as $A \cdot B$, defined as:

$$A \bullet B = (A \oplus B) \Theta B. \quad (5)$$

Defect repair method based on mathematical morphology, the shape and size of structure element B are directly affect the effect of defect repair. Structural elements of different shapes (round, square, or diamond) have different sensitive levels to noise and defects, the shape of structural elements should be based on the specific circumstances of the defects. If using a shape of structure element cannot produce satisfactory results, varieties of shape structure elements can be used at the same time, have respectively operation on images, and then combine the image operation. The size of structure elements also has an effect on the effects of defect repair, in general, the small size of structural elements has weak ability of denoising, but the protection of the edge details is good; large size of structural elements has stronger ability of denoising, but the protection of the edge details is poorer. Accordingly, when selecting structural elements two aspects of size and shape should be considered, and determine structure elements according to the specific condition of defects. The operation forms adopted (expansion, corrosion, open and closing) also has a great influence on the effects of defect repair. Generally speaking, the expansion can make goals increases, narrow hole; Corrosion can shrink the boundary of the image, and make the inner hole enlargement, eliminate external noise isolation; Open operation can cut thin lap and get rid of the solution domains, burrs and protruding parts; Close operation can fill the small holes, lap short intervals, and connecting adjacent objects. In practice, the choice of the operation forms should follow the following principles:

a) Smoothen boundary, eliminate the tiny holes and burr in the images on the basis of keeping the basic shape features;
b) In order to ensure the accuracy of measurement, the size of the image in the target should basically remain unchanged.

In practice, the above principles should be according to, choose the appropriate operation form as to the specific situation of defects, when necessary, the combination of a few basic operation forms can be used.



3	2	1
4	P	0
5	6	7

FIGURE 2 The direction chain code of pixel P

D. Outline of chain code

Binary images translate the original array form into description of boundary contour point after contour extraction, due to the contour point itself represents the boundary of the graphics area, does not indicate the relations between graphics area and border, therefore, contour tracking technology must be used to extract the contour tracking, and contour information should be stored in a certain form, in order to facilitate the processing and measurement of contour. This article adopts the method of chain code tracing to store the outline of image information.

Chain code is a kind of improved sequence storage structure of coordinate's increment. As shown in Figure 3, chain code can be defined through the centre pixel P to point to the direction of eight adjacent points direct to it, chain code value plus 1 means 45 counter clockwise. For contour image, besides the pixel sequence starting pixels, any subsequent pixels can be confirmed available by one of 0 ~ 7 pixels. Contour tracking can be in accordance with the direction of the chain code, the acquirer of next tracing point depends on the last contour point, so as to avoid the scan of all pixels, which improves the efficiency of contour tracking [5].

Chain code tracking process is as follows:

(1) Adopt the line scan technology to get the outline of starting point, record the point coordinates of the Start-X and Start-Y, and take this starting point as the current point, turn to step (2), if cannot get contour points after scan, turn to step (4);
(2) Sequential scan the 8 neighbourhood adjacent with current point according to the direction of the chain code, if encountering contour points, immediately stop tracking contour and recording the track to the direction of the chain code value, turn to step (3); If not, set the sign of end of contour tracking "-", set up the scan starting place as Start - and Start X - Y, and turn to step (1);
(3) Filled with ground colour to fill contour points that are scanned, set up and the current point as the tracked contour points, turn to step (2);
(4) Use "-" to sign all end of contour tracking.

In this way we can get chain code sequence List of all the contour information. The format of the chain code sequence includes the coordinates of the starting point and direction chain code values, contour end marks are used between different contours to separate. The record way is: to a closed contour, the first is contour coordinates of starting point, and then is the direction chain code sequence, then is the contour end mark. Because of the use of the outline track, the values in the sequence are recorded in the order according to the contour lines, which provides convenience for subsequent processing of contour. Chain code tracing method can realize getting all the outlines by one tracking.

Chain code according to the outline of the value can be completed through the chain code decoding work, the idea of decoding are the same with encoding. The relationship between direction of the chain code and the pixel coordinates of the corresponding is shown in table 1, thus an

array can be constructed to complete the decoding process, construct array X[8] to X coordinate, X[8]={1, 0, 1, 1, 1, 1}; construct array Y[8] to Y coordinate, Y[8]= {0, 1, 1, 1, 0, 1, 1, 1}. Then the corresponding contour coordinates can be got through chain code sequence. The experimental result is shown in Table 1.

TABLE 1 The corresponding relationship between Chain code values and pixel coordinates

Chain Code Value	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*
X coordinate offset	1	1	0	-1	-1	-1	0	1
X coordinate offset	0	1	1	1	0	-1	-1	-1

In order to examine the effects of contour extraction, a vase image is selected (gray level 256) as a test image, to have contour extraction experiments, the results shown in Figure 4.

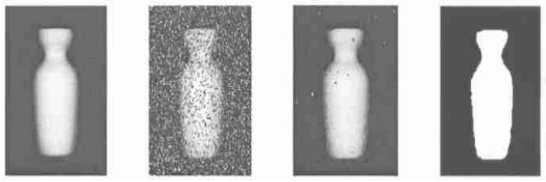
(a)original image; (b) threshold segmentation image; (c) extractive outline

FIGURE 3 The image contour extraction results

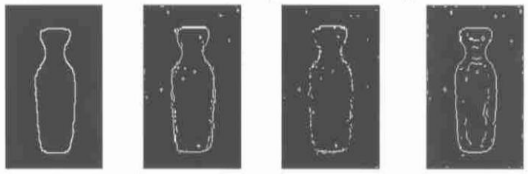
As the experimental result is shown, it can be observed that when the image is out of interference, the textual method is good for the extraction of image contour.

In order to verify the practicability of this method and its sensitivity to noise,the image of Figure 3 (a) is added into 20% of impulse noise as (FIG. 4 (b)), and get Figure 4 (c) after the image preprocessing (median filtering), Figure 4 (c) is taken as the test image, to carry on image contour extraction experiments, and the experimental results are compared with extractive edge method of the Sobel operator, Roberts operator, Canny operator, the results are shown in Figure 4.By the experimental results it can be seen that in the case of image noise disturbance, the result of the contour extraction of Sobel operator (FIG. 4 (f)), Roberts operator(FIG. 5 (g)), Canny operator (FIG. 4 (h))are bad, in which breaking stitches and noisy phenolmenon exist, and textual method (FIG. 4 (e)) still can extract the image contour well..

Experimental results show that the proposed image contour extraction method has a certain practicability and anti-noise ability, and is able to meet the needs of the measurement technology based on computer vision.



(a) original (b)20% noise (c) median filtering (d) repaired



(e) textual (f) Sobel (g) Roberts (h) Canny

FIGURE 4 Image contour extraction results comparison after adding noise.

5 Conclusions

It is can be seen from the experimental results, the use of shared-nothing architecture system can bring more excellent performance. The system only needs to add in the new common node query performance which can be achieved near-linear effective upgrade. This feature can help database system accommodate the massive data since the analysis and processing scenarios require rapid query performance improvement. The system only requires the addition of processing nodes based on performance to meet the performance requirements of the query. It should be noted that, due to limited capacity of the data loaded in the file server, its performance does not increase linearly.

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