Application of 3D Dynamic Image Technology in Industrial Products

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Abstract. Aiming at the problems of manual testing of industrial products, a measurement method of industrial products based on three-dimensional dynamic imaging technology is proposed. The products on the production line are dynamically photographed from different angles and within a certain period of time by using cameras. Then the obtained Image denoising processing and contour tracking based on chain code table and line segment table to obtain boundary information and regional information of each enclosed area of the image. Experimental tests show that the test accuracy of this method is 100%, which is suitable for real-time detection. Fully automated research on product testing provides the foundation.

Keywords: 3D Dynamic Image Processing, Product Inspection, Characteristic Parameters, Chain Code Table, Line Segment Table

1. Introduction
At present, the method of manual measurement is mostly used to test whether the geometric characteristics of the subordinate products are qualified [1,2]. This method is due to the large errors in the measurement operation and manual reading and it is time-consuming and labor-intensive [3,4]. Castor reduces the industrial production efficiency [5,6]. Therefore, this paper proposes to use a camera to monitor the production line in real time, take pictures of each product regularly, and perform automatic processing [7,8]. Calculate the geometric characteristic parameters of the product, and then compare it with the standard specifications. Compare, and perform alarm marking processing for products that do not meet the requirements [9,10]. It is convenient to manually remove them.

2. Three-dimensional dynamic image processing flow
The CCD camera is used to obtain the images of the products on the production line from different angles according to the needs. If the error of the measured maximum value is within the allowable range, the product geometry The feature detection is passed and marked as qualified: If the error of the measured value exceeds the allowable range, a warning sound will be issued and the image will be marked to remove unqualified products. The three-dimensional dynamic image processing flow is shown in Figure 1.
2.1. Contour tracking

The chain code table is generally defined by the direction in which the central pixel points to its 8 neighbors. As shown in Figure 2(a), the chain code takes a value of 0–7. It increases in the counterclockwise direction. It is 8 connected chain codes. It also points to 4 The chain code of the neighboring point, as shown in Figure 2(b), has a value of 0–3, which is a 4-connected chain code. Here, an 8-connected chain code is used.

![Diagram of 8-connected chain code and 4-connected chain code](image)

**Figure 2. Definition of chain code**
The chain code table is used to store the coordinates of the starting point of the area boundary and the chain code sequence data of each boundary point connected thereafter. The first and second units of the chain code table store the X and Y coordinates of the starting point of the boundary, and the third unit stores the number of points on the boundary, the 4th unit starts to store the chain code sequence.

The area can also be described by multiple horizontal line segments. The scan mark method is used to obtain the area information. In this case, the line segment table structure is used to store the area information. The line segment table is composed of an endpoint table obtained by all the horizontal line segments in the area arranged in the scanning order. 2 adjacent endpoints represent 1 horizontal line segment.

The horizontal direction is to enter this point. The vertical direction is the chain code leaving this point. "0" in the table indicates that this point is the middle point. "1" is the left end point, "2" is the right end point, and "3" is the singular point (Table 1).

The contour tracking is divided into the following 4 steps:

1) Scan the entire image line by line. If you encounter an object point in a binary image, start 8-connected tracking with this object point. Complete single area tracking, and fill in the chain code table when tracking:

2) Convert the chain code table obtained in step 1) into a line segment table;

3) Use the line segment table obtained in step 2) to fill the tracked single area with colors other than black and white binary values:

4) Return to step 1) Continue tracking until the entire image is tracked.

**Table 1. Conversion table**

| Incoming chain code | Leaving chain code |
|---------------------|--------------------|
| 0                   | 0                  |
| 1                   | 1                  |
| 2                   | 1                  |
| 3                   | 1                  |
| 4                   | 1                  |
| 5                   | 0                  |
| 6                   | 0                  |
| 7                   | 0                  |

|                    | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|--------------------|---|---|---|---|---|---|---|
| 0                  | 0 | 0 | 0 | 2 | 2 | 2 | 2 |
| 1                  | 1 | 1 | 1 | 1 | 0 | 3 | 3 |
| 2                  | 1 | 1 | 1 | 1 | 0 | 0 | 3 |
| 3                  | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 4                  | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 5                  | 0 | 3 | 3 | 2 | 2 | 2 | 2 |
| 6                  | 0 | 3 | 3 | 2 | 2 | 2 | 2 |
| 7                  | 0 | 0 | 3 | 2 | 2 | 2 | 2 |

2.2. Calculate geometric feature parameters

1) Area S.

The area area is the sum of the length of each line segment in the area.

\[
S = \sum_{i=1, j=2}^{n} (D_{i+1}x - D_jx + 1)
\]  

(1)

In the formula, n is the total number of end points of the area line segment, \(D_{i+1}x\) represents the X coordinate of the right end point of the \((i+1)/2\)th line segment.

2) Circumference L.

The perimeter is the number of pixels at the boundary of the target area. Using the chain code table, the perimeter is the sum of the odd multiplied by \(\sqrt{2}\).

\[
L = n_e + \sqrt{2}n_o
\]  

(2)

Because the even chain code segment is a vertical or horizontal code segment, the odd chain code segment is a diagonal segment. Therefore, the odd number must be corrected with the weight of \(\sqrt{2}\),
and the correction of the length of the boundary can compensate for the discretization error of the image.

3) Shape factor C
The shape factor describes how similar the area is to the circle. The greater the difference between the shape factor and 1, the greater the difference between the shape and the circle.

\[ C = L^2 / 4\pi S \] (3)

In the formula, L is the perimeter and S is the area.

4) Center of gravity (X, Y)
The line segment table can be used to calculate the X-direction moment and Y-direction moment of each line segment, and the coordinates of the center of gravity can be averaged after accumulation. That is, the X and Y coordinates of the center of gravity are:

\[ X = \sum_{i=1, j=2}^{n} \left( D_{i+1}x - D_{i}x + 1 \right)(D_{i+1}x + D_{i}x) / 2S \] (4)

\[ Y = \sum_{i=1, j=2}^{n} \left( D_{i+1}y - D_{i}y + 1 \right)D_{i}y / S \] (5)

In the formula, \( D_{i+1}x - D_{i}x + 1 \) is the length of the \((i+1)/2\)th line segment. \( (D_{i+1}x - D_{i}x + 1) \times (D_{i+1}x + D_{i}x) / 2 \) is the accumulation of moments in the X direction, \( (D_{i+1}y - D_{i}y + 1)D_{i}y \) is the accumulation of moments in the Y direction, and S is the area of the region.

5) Circumscribed rectangle (W, H)
The circumscribed rectangle describes the smallest rectangle size of the area occupied by the area. Its width W and height H can be calculated from the line segment table:

\[ W = \max \left( D_{x_1}, D_{x_2}, \cdots, D_{x_n} \right) - \min \left( D_{x_1}, D_{x_2}, \cdots, D_{x_n} \right) \] (6)

\[ H = D_{y_{n-1}} - D_{y_1} \] (7)

3. Experiments and results
The experiment takes a round fruit plate as the test object, randomly tests 100 images, and calculates their geometric characteristic parameters. The test results of 5 of them are shown in Table 2 (the unit of area, perimeter, and circumscribed rectangle is the number of pixels). Show.

| Serial number | Area  | Perimeter | Shape parameter | Center of gravity | Circumscribed rectangle |
|---------------|-------|-----------|-----------------|-------------------|-------------------------|
| 1             | 10226 | 376       | 1.100171        | (77,64)           | (113,113)               |
| 2             | 10226 | 376       | 1.100171        | (77,64)           | (113,113)               |
| 3             | 10226 | 376       | 1.100171        | (77,64)           | (113,113)               |
| 4             | 10227 | 377       | 1.105922        | (77,64)           | (113,113)               |
| 5             | 10226 | 376       | 1.100171        | (77,64)           | (113,113)               |

The test accuracy rate obtained from the above data is 100%. The experiment shows that the image geometric feature extraction method used in this paper can accurately calculate the geometric. According to the different appearance characteristics of the product, from Taking pictures from different angles and processing three-dimensional dynamic images can comprehensively determine the required geometric characteristic parameter values.
4. Conclusion
The three-dimensional dynamic image processing method used in this paper can fully detect the geometric features. Although there are few test objects, it can explain its feasibility and accuracy to a certain extent. In addition, industrial products have other parameters and specifications, even the uniformity of the material, the degree of smoothness, whether there is damage, etc. This article only provides the detection method for the appearance. Future research and realization will provide the foundation.

Acknowledgments
1. Research and design of virtual tourism project of Tangzhua ancient town in Nantong(MSZ18030);
2. 4th batch of young and middle-aged scientific research backbones(ZQNGG410).

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