Research of Industrial Parts Measurement Algorithm Based on Computer Graphics

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Abstract. This paper presented a research method for industrial product detection system based on computer graphics. The method is applied an idea which combine fuzzy theory in edge detection with computer graphics, and it realized the automatic detection of industrial product appearance size on the production line. The industrial detection system is established by non-contact way, and it had great superiority in the accuracy, reliability, flexibility and automation, real-time, etc. it can satisfy the needs of high precision of industrial detection.

Introduction

With the advancement of industrial technology and the market competition is increasingly fierce. It is the appearance of the product, appearance design, internal quality and other factors are only attributed to quality of products. Higher requirements are put forward in product quality control. Industrial components detection system as the main part of the product quality control, its performance and function played is good or not directly affects the product quality control and production efficiency at some level.

Aiming at this problem of length measuring, Jia [1] presented a industrial inspection method of the digital close-range photographer methods. He used two or more industrial camera, can make industrial components detection of three- dimensional parameters. Miao [2] put forward a method of prepossessing image by using median filter, and it combined Hough transformation with Sub-pixel detection. It got better results, but the process is more complicated and can’t satisfy needs of two-dimensional length detection in industrial production process.

However, this paper presented a method which applied the digital camera and fuzzy theory in edge detection. This method overcame the problem which is standards of product sample selection, and time lag in the testing process in previous product. It not only can detect the two-dimensional length of the industry parts, but also satisfy high precision, high efficiency and automation.

Part Image Acquisition Principle

Aiming at testing of steel cord fabric for the processing factory, the paper realized the measurement of steel cord fabric size without affecting the basic production efficiency. It detected contour length of the product parts on the fixed position on the production line. At first, the parts contour shape is obtained by camera. Then all size parameters which are needed are obtained through image processing by PC, and the processed image the output parameters are displayed on LCD. At the same time, compared between the detection values and standard, if there is error, will feedbacked to PLC module, and the front equipment will correct the error accordingly.

The Principle of Parts Edge Image Acquisition

The contour shape of parts on the production lines is obtained applying fuzzy theory. Because of the uncertainty of the visual information, image information and the fuzziness of image edge defining, the fuzzy theory is introduced into the pattern recognition of different levels, which is used to describe the fuzziness and randomness of human visual system. For the first time in 1983,
Pal and King, the fuzzy theory is introduced into the image edge extraction algorithm in [3-5], generally referred to as the classical fuzzy edge detection algorithm. The center of the algorithm is which increase the contrast between the different area with fuzzy enhancement technique. It improved the gray contrast of the edge on both sides, and extracted fuzzy edge. The basic steps for:

1) $x_{ij}$ is a pixel gray-scale for $(i, j)$, and $x_{\text{max}}$ is the biggest gray scale. Images can be obtained by the membership function of fuzzy characteristics, can be represented as in Eq. (1).

$$P_{ij} = T(x_{ij}) = \left[ 1 + \frac{x_{\text{max}} - x_{ij}}{F_d} \right]^{-F_e}. \quad (1)$$

Among them, $F_e, F_d$ exponential factor and reciprocal type factor, respectively, determine the value of $P$ in the plane of the characteristics of fuzziness size, among them, as in Eq. (2).

$$F_d = \left| \frac{x_{\text{max}} - u_c}{2F_e - 1} \right|. \quad (2)$$

The type of the definition of fuzzy feature plane $p_{ij}$ will specifically said the first $(i, j)$ has the biggest a pixel gray-scale level.

2) will be under test image map for fuzzy characteristic matrix $X = \bigcup_{i=1}^{M} \bigcup_{j=1}^{N} p_{ij} / x_{ij}$, $p_{ij}$ is a fuzzy feature, in this algorithm, the fuzzy characteristics of pixels of relative gray value.

3) after obtain image fuzzy plane, carries on the fuzzy enhancement, namely the original fuzzy characteristic function $p_{ij}$ nonlinear transformation to a K time, usually for contrast enhancement transformation. In general, for A fuzzy set A do enhancement transformation, will produce A new fuzzy set B = INT (A).

Its membership function is as in Eq. (3).

$$\mu_{B}(x) = \begin{cases} 2(x_{ij})^2, & 0 < x_{ij} < r \\ 1 - 2(1 - x_{ij})^2, & r < x_{ij} \leq 1. \end{cases} \quad (3)$$

This kind of transformation is the result of the fuzzy set A ambiguity is reduced, increased the value of the $\mu_{A}(x)$ above $r$ also reduced the value of $\mu_{A}(x)$ below $r$.

This can be represented as fuzzy enhancement algorithm, as in Eq. (4).

$$p'_{ij} = I_r(p_{ij}) = I_i(I_{r-1}(p_{ij})), r = 1, 2, 3... \quad (4)$$

4) The application of the fuzzy characteristics of the domain will be enhanced inverse transformation matrix, the fuzzy characteristics of the matrix transformation from fuzzy space for the data space, or the "Max" reuse "min" operator to extract the edge, get the edge image collection.
\[ \text{Edges} = \{I^M_{mn} \}_{M \times N} \]
\[ I^M_{mn} = \left\{ \frac{I_{im} - \min_j \{I^M_{ij}\}}{(i,j) \in Q} \right\} \]
\[ I^M_{mn} = (K-1)p_{mn} \]

Among them, the point Q is (i, j) as the center of 3 × 3 area, as in Eq. (5).

In the algorithm implementation process, set \( u_c = 0.45 \), transit fuzzy enhancement for \( K=2 \), the results of the selected image edge extraction algorithm and other contrast is shown in figure 1.

![Figure 1](image1.png)

Figure 1. Related algorithm contrast.

Figure by the result of the experiment, it can draw the conclusion: in this paper, the fuzzy mathematics theory foundation of edge extraction method has a strong select good parameters can significantly eliminate noise, and accurately positioning to extract the image edge, but according to the different effect and precision of image contains information is different, different areas with different image or not are universal, this is a transit point location selection of arbitrary decision. In the operation of different measurement, need to adjust the transition point parameters repeatedly, to achieve the best effect.

**Parts Image Morphology Identification Principle**

Definition 1, the characteristics of the image edge pixel value refers to the pixel with another point has certain specific pixel edge distance of horizontal ordinate bad difference. And according to the specific characteristics of pixels value following points, and margin call the edge distance characteristics, the pixels with the characteristic value following points from the linear distance between called features.

![Figure 2](image2.png)

Figure 2. Characteristic value of schematic diagram.

This paper analyses all assumptions for counterclockwise. Illustrate the definition. The shown in figure 2 for the quadrilateral, the coordinates of the edge of a pixel point P \((x, y)\). Assume here the characteristics of the margin to \( d \), then the characteristic value following point as the starting from the current pixel point P, along the edge of \((x_i, y_i)\) to (set as anticlockwise) forward the distance \( d \) after get the pixel point \((x_i, y_i)\), the pixels can be found through the edge tracking, point P characteristic value of \( \lambda_p \) to \( \|x-x_i\| - \|y-y_i\| \).
According to this definition, obviously has the following theorem.

Theorem 1: if both edge points and follow on the same line, then the two edge points at the same eigenvalue.

Prove that amplify the polygon assertive $P_1$ area is shown in figure 3.

![Figure 3. Multiple edge point eigenvalue.](image)

According to the definition, $P'$ for the eigenvalue of the point $P$ to follow point, point $P$ eigenvalue of $\lambda_P = \left| O_1P - PO \right|$; $Q$ to $Q$, the eigenvalue of the following points, the eigenvalue of the point $Q$, $\lambda_Q = \left| O_1Q - QO \right|$; $Q'$ for the point $Q$ characteristic value following points, the eigenvalue of the point $Q$, $\lambda_Q' = \left| O_1Q' - QO \right|$, $P, P', Q, Q'$ points are on a straight line, $\triangle PO_1P' \cong \triangle QO_1Q'$, $\left| PO_1 - O_1P' \right| = \left| QO_2 - O_2Q' \right|$, is a $P$ and $Q$ at the same eigenvalue. Point $Q$ and $Q'$, $P, P'$ is not on the same line, so the eigenvalue of the $P$ and $Q$ are different.

According to theorem 1, obviously has the following corollary.

Corollary 1 the pixel value of edge characteristics on the curve always changing.

By theorem 1, figure 3 pixel point on the line $PP_1$ eigenvalue approximate equal, but after clockwise $P_1$ pixels with $P$ and eigenvalue changes, until the pixels and eigenvalue with points on a straight line, the pixels with a vertex distance than before when margin features, characteristic value again tend to be equal.

Theorem 2, according to the features of defined margin for $d$, to each edge of a polygon, as shown in figure 4 $P_1P_2$ into two lines, set to $PA$ and $A_1P_2$, set the length of the $PA$’s $d$ (assuming the edge pixel in the recognition process of direction is clockwise), another for $A_2P_2$, length of $PA_2 - d$, then the pixels on the $PA$ eigenvalue have great changes, the pixels on the $A_2P_2$ eigenvalue approximate constant.

![Figure 4. Characteristic values change.](image)

Proof: the polygon is shown in figure 4, in the process of the recognition of the polygon characteristic margin for $d$.

Might as well analyzes edge $P_1P_2$ According to the characteristics of distance $d$, while $PA$ and $A_2P_2$, $P_1P_2$ divided into segments, including $PA$ length is $d$. Obviously, on line $PA$ pixels and its characteristic value following points not $PP_2$ straight line, so it has the characteristics of the pixel value changes. The $A_2P_2$ pixels and its characteristic value following the point on the line segment in $PP_2$ straight line, so have the same eigenvalue.

According to theorem 2, obviously has the following corollary.

Corollary 2, polygon before each vertex of a number of edge pixels eigenvalue of approximately equal, then the characteristics of edge pixels within the margin of characteristic values change.
Corollary 3, set the eigenvalue of the polygon edge pixels in order form s cycle sequences, s characteristic value by approximately equal to the change in the transformation of the frequency is equal to the number of polygon vertical.

**Parts Measurement Algorithm Steps**

According to the theorem and inference, the processing parts size detection system, build a edge pixels based on fuzzy theory and the characteristic value of geometry detection algorithm, the process is shown in figure 5.

![Figure 5. The procedure flow charts.](image)

A) input images of the need to deal with, through to the original image fuzzy mapping, and get a fuzzy characteristic matrix G; B) to the appropriate nonlinear characteristic matrix transformation and inverse transformation processing, change the fuzzy matrix, fuzzy enhancement image information, weaken the edge information; C) in the end, "min" or the "Max" operator was used to extract the edge; D) will be closed with complete edge geometry, according to the graphics and image gray-scale differences identified graphic edge, constitute the edge pixel edge; E) preachment edge, along the edge of the graphics inside traversal collection edge, delete redundant edge pixels, ensure each edge pixel in ongoing diagram and only two adjacent pixels, edge 'get set; F) traverses the edge pixel set edge margin d, according to the given characteristics, the characteristic value of each of these points, constitute the eigenvalue of the circulation order collection eigenvalue; G) traversal eigenvalue collection eigenvalue, according to the characters of the theorem and inference calculation edge pixel value transform position and number, and each time the distance transform continuous; H) if there are n transformation, and each transformation characteristics of distance equals margin continuously, can judge the graphics for the n side, the first pixel of each transformation is the vertical, all vertex of orderly collection, transform the total number of the polygon number of edges and vertical, continuous two change points as the distance between the length of the corresponding image pixels; I) if there are n transformation, and constant distance is not equal to at least one transform characteristics of margin, then this graphics for polygon with arc segment, n is the number of straight line and arc while and, the first pixel of each transformation for vertex or arc segment starting point.

**Algorithm Simulation Results**

In this paper, we use visual studio 2012 to the implementation of the algorithm, the experiment by using the computer is configured to AMD Athlon CPU 1.4 GHz/memory 1 GB, in figure 6 physical image recognition, by detecting objects for a standard specifications of steel wire cord fabric, the shape of parallelogram, two pairs of edge length is 500 mm and 445 mm respectively, gained by the original image size is 1392 x 465, processing results are shown in figure 7.
After alignment with actual measurement, can be easy to see that the error of the processing method of this paper can achieve within 1 pixel, specific processing accuracy depends on the photographic equipment to the distance of the object being measured physical parameters, such as, even so, the accuracy can reach the level of + / - 0.1 mm, usually can achieve most of the industrial product testing requirements.

Table 1. Algorithm identification results.

<table>
<thead>
<tr>
<th>The processing time(ms)</th>
<th>671</th>
</tr>
</thead>
<tbody>
<tr>
<td>The edge pixel points</td>
<td>2770</td>
</tr>
<tr>
<td>Graphic type</td>
<td>Polygon, four vertical</td>
</tr>
<tr>
<td>Each vertex coordinates</td>
<td>(752,115)(21,174)(1391,244)(660,297)</td>
</tr>
<tr>
<td>Each side pixel points</td>
<td>733,651,733,652</td>
</tr>
</tbody>
</table>

Conclusions

For the specific requirements of industrial products testing, fast and practical automatic detection method is proposed. The proposed image feature recognition method based on fuzzy theory, with the aid of computer graphics, image processing and analysis, and into the extract and display the image of the main data, in order to realize the automation of industrial production of industrial products 2 d detection. By the simulation and actual experimental comparison, the method has good precision and operation speed, high degree of automation, the production efficiency of the original little impact, can meet most of the front end of industrial production line of the length of the basic product testing requirements.
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References


