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An In-process Machine Vision Detecting System in Continuous Machining

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Abstract: - In continuous machining, batches of wasters have been manufactured if the machine worked wrong before the inspection. It is necessary to develop in-process detecting techniques for products' quality control. So a high-speed machine vision system for auto detecting defects in continuous machining is designed in this paper. The perimeter of product's edge and Euler number of the image are measured as detecting parameters. The customized wavelet transform for edge detection is proposed in this paper. The above image's characteristics are chosen as input vectors of this machine vision system, and 50 various images of each defect type are chosen as training samples, the recursion least square law is used to train this system. This system is successfully used to detect various defects of the products on line and the detection rate achieves more than 95%. The advantages of this system may be seen as lower cost, less bulky, greater resolution, and flexibility.

Key-Words: -Machine vision, Wavelet Transform, In-process Detecting

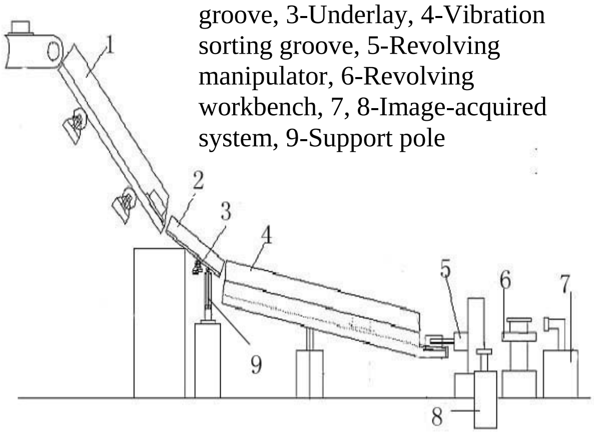
1 Introduction

Most continuous machining cycles include an inspection step to ensure products' quality achieve the standard which must stop the machine at regular intervals. In continuous machining, batches of wasters have been manufactured if the machine worked wrong before the inspection. It is necessary to develop in-process detection techniques for online quality control. Recent development of machine vision techniques helps to solve this problem [1], [2]. So a high-speed machine vision system for auto detecting defects in continuous machining is designed in this paper. The covers of crystal oscillators are chosen as research objects. The main advantages of optical inspection methods are their ability to scan large areas, their applicability to in-process inspection, and their ability to perform fast inspection [3], [4].

2 Components of the System

The main components of the machine vision system designed in this paper are shown as Fig 1.and Fig 2.

1-Products conveyer, 2-Sampling groove, 3-Underlay, 4-Vibration sorting groove, 5-Revolving manipulator, 6-Revolving workbench, 7, 8-Image-acquired system, 9-Support pole



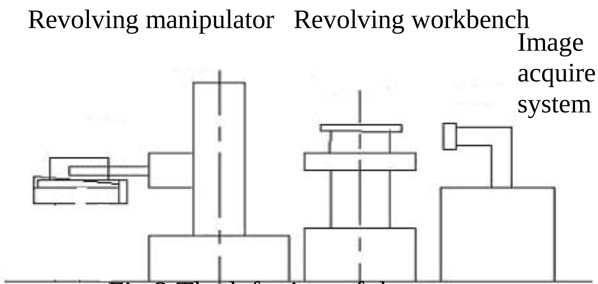
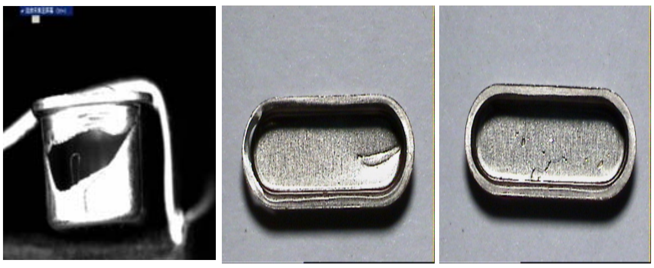


Fig.2 The left view of the system

When sampling groove 2 is working, products are transported from products conveyer 1 to sampling groove 2 and then to vibration sorting groove 4 where these products are still in disorder at this time. The vibrator, however, causes vibration sorting groove 4 to vibrate, thus making the products continuously moving down the substrate of vibration sorting groove 4 and inserted into this groove because this groove and the products are of the same size. Then, they are adjusted to relatively positioned, and transported into a plane orientation groove. These products are clasped by revolving manipulator 5 from this plane orientation groove, and transferred to the first image-acquired system 7 that is used to acquire images from the underside and the top. Then, the revolving manipulator 5 moves them to revolving workbench 6.Images of sides are acquired by the second image-acquired system 8. The defects in these products are detected by analysis of these images, which confirms whether the machine is good or not.

3 Analysis of Acquired Images

The covers of crystal oscillators have three types of defects in product lines, which are breakage, flex crack and points on cover. Their images are shown as Fig.3.



(a) Broken cover (b) Flex cracked cover (c) Points on cover

Fig.3 The classic types of defects in shells of crystal oscillators

In the property of topological, the definition of Euler number and the operator of description region is the number of holes subtracted from the number of connected objects. H is taken as the number of holes of one image and C as the number of connected parts of the image. Euler number is defined as:

$$E=C-H \tag{1}$$

If the cover of crystal oscillator is broken, the brightness of the broken region is different from other regions, so H is not equal to zero; E is not equal to 1, then the program return 0 states, otherwise 1 state. If the result is 0, turn on the yellow status light, which express the product is bad, then end the program and stop the machine; otherwise go to the next detecting step. So calculating Euler number can detect broken covers.

If the cover of crystal oscillator has been flex cracked, the perimeter of the edge is different to which of good product. So this type of defect can be detected by means of measure the perimeter of the edge. But the edge line must be detected firstly.

Too much noise that produced by the complex process of machining makes the traditional edge detect algorithm such as Roberts, Sigma, Differentiation and Prewitt undesirable. In this paper, an algorithm of edge detection using wavelet transformation is proposed.

$\psi(x)$ is called a wavelet if its average is equal to 0. The DWT can be designed as a multiscale edge detector that is equivalent to Canny edge detector.

Suppose that is a differentiable smooth function whose integral is 1 and converges to 0 at infinity. Let wavelet $\psi(x)$ be the first order derivative of $\theta(x)$.

$$\psi(x)=d\theta(x)/dx \tag{2}$$

Then

$$W_j f(x)=f*\psi_j(x)=f*\left(2^j\frac{d\theta_j}{dx}\right)(x)=2^j\frac{d}{dx}\left(f*\theta_j\right)(x) \tag{3}$$

The wavelet used in this paper is the Mallat wavelet (Mallat and Zhong, 1992). The corresponding $\theta(x)$ is a cubic spline, and thus $\psi(x)$ is a quadratic spline.

$$\theta(x)=\begin{cases}0 & |x|\ge 1\\ \theta(-x) & 0\le x\le 1\\ -8x^3-8x^2+4/3 & 0.5\le x\le 0\\ 8(x+1)^2 & -1\le x\le -0.5\end{cases} \tag{4}$$

$$\psi(x)=\begin{cases}0 & |x|\ge 1\\ -\psi(-x) & 0\le x\le 1\\ -24x^2-16x & 0.5\le x\le 0\\ 8(x+1)^2 & -1\le x\le -0.5\end{cases} \tag{5}$$

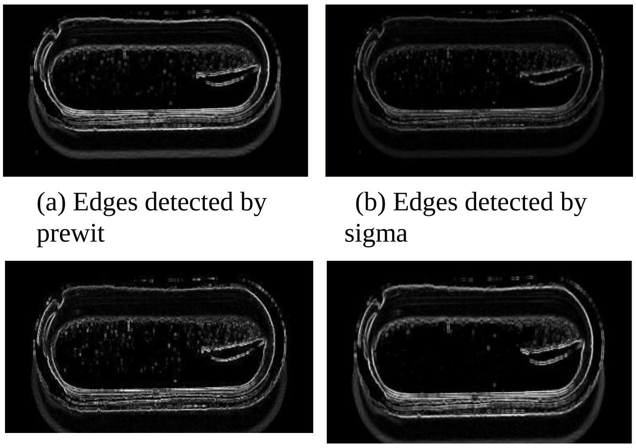
In the case of images, $\psi^1(x,y)$ and $\psi^2(x,y)$ should be utilized. Suppose $\theta(x,y)$ is a 2-D differentiable smooth function whose integral is 1 and converges to 0 at infinity. The two wavelets are:

$$\psi^1(x,y)=\frac{\partial\theta(x,y)}{\partial(x)}\quad \psi^2(x,y)=\frac{\partial\theta(x,y)}{\partial(y)} \tag{6}$$

Denote

$$\zeta_j=2^{-2j}\zeta\left(2^{-j}x,2^{-j}y\right) \tag{7}$$

The dilation of $\zeta(x,y)$ by 2^j, the WT of f (x,y) at scale 2j and position (x,y) has two components.
The result image of edge detected by above wavelet transformation is compared with that of traditional edge detection algorithm such as Roberts, Sigma and Prewitt. Fig.4 shows it.



(a) Edges detected by prewit

(b) Edges detected by sigma

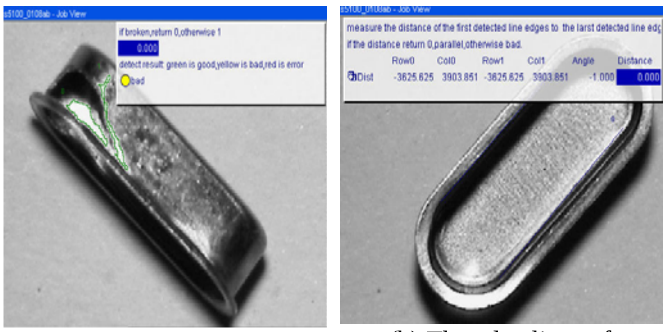
(c) Edges detected by Roberts

(d) Edges detected by DWF

Fig.4 The result image of edge detection

4 The main program and result

Fifty various images of each type are chosen as samples in the experiment.
Fig. 5 only shows the detected results of the two classic types of defects.



(a) Euler number of the broken cover

(b) The edge lines of flex cracked cover

Fig.5 Detected results of the two classic types of defects

The flowchart of main program is shown as Fig.6.
This system uses the recursion least square law to do decision-making and it is successfully detect various defects of the products on line and the detection rate achieves more than 95%.

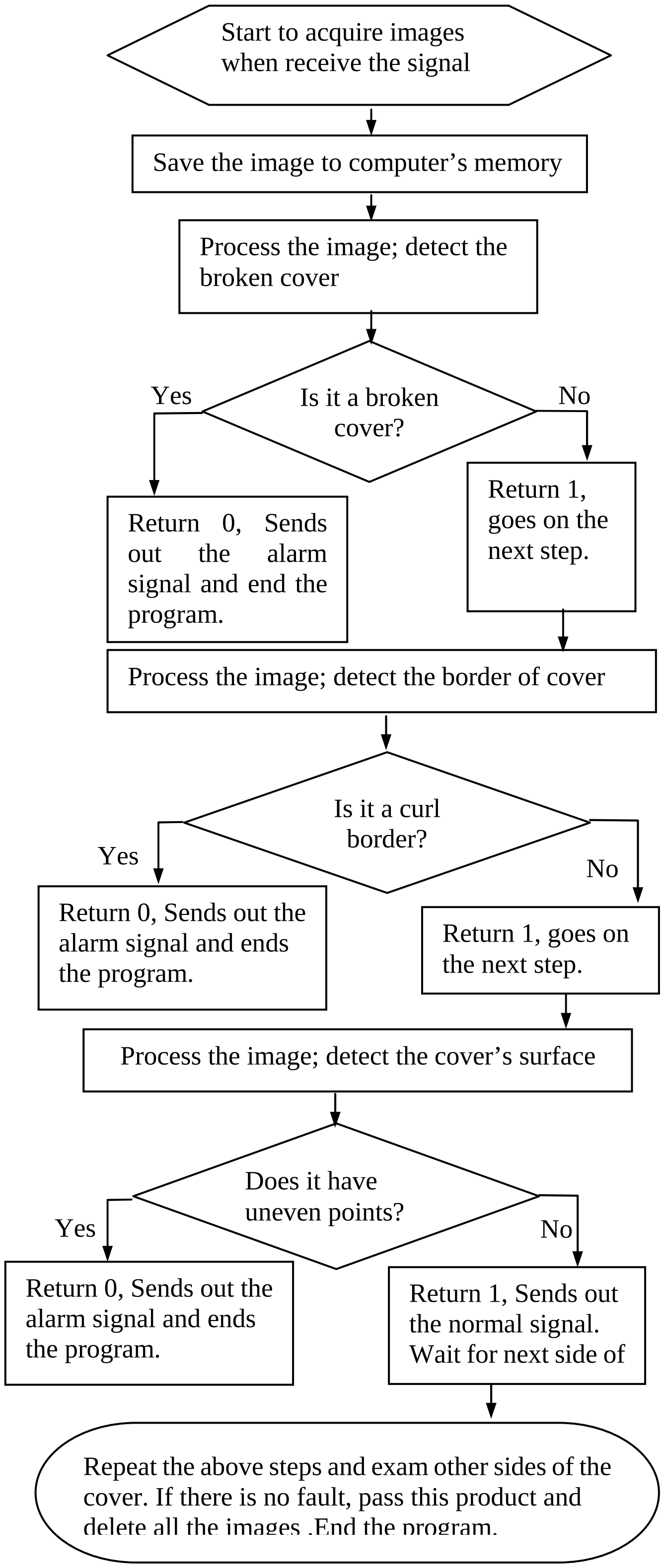


Fig. 6 The flowchart of main program

5 Conclusion

(1) A high-speed machine vision system has been designed for auto detecting defects in continuous machining.
(2) Calculating Euler number can detect broken products, especially covers of crystal oscillators.
(3) The result image of edge detection shows that the wavelet transformation algorithm proposed in this paper is better than traditional edge detection algorithm such as Roberts, Sigma and Prewitt.
(4) The experimental results show that this machine vision system can detect the three types of defects of crystal oscillators' covers accurately and quickly. It improves the productivity and reduces the product cost in continuous machining.

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