Research on the robot vision system for Detecting defects of the cover of crystal oscillators

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Abstract: - Machine vision systems are being used in automated industrial manufacturing environments to determine surface defects with the development of the image process technology. This paper deals with the design and development of a new high-speed machine vision system to detect defects of the cover of crystal oscillators. The component of the robot vision system is given and discussed first. Then image processing technology is presented for detecting the edge of acquired images in this paper. Through calculating the defect area of the image，the defects defecting is achieved. So the automatization manufacture is realized. The results show this system is successfully to detect two kinds of defects of the crystal oscillators' cover. The advantages of this new system are lower cost and high flexibility.

Key-Words: –Robot vision system, Defects detecting, Metal manufacturing, Image processing, Wavelet transforms.

1 Introduction

In the recent decades, the crystal oscillator has already been applied widely in broadcast, communication, electron measuring, aviation, spaceflight, etc. So the quality of manufacturing covers of crystal oscillators has been demanded stricter and stricter. But the enterprises of manufacturing covers of crystal oscillators have not a better system that could detect defects of these products online at present. Operators often find out the defects after manufacturing one batch product, which increased the production cost greatly.

As covers of crystal oscillators are little metallic objects，there are concealed defects which are difficult to find using common instruments. These defects are practically examined with the instruments utilizing radioactive material or X-ray in field applications. However, the instruments are expensive, and handling the hazardous material causes a variety of problems. The defect detection in process industries employing metallic equipment and structure is an important procedure of maintenance. In spite of the importance, the limitation of proper detection technique incurs restricted examination of the material in the industries. Recent development of machine vision defect detection can be used to solve the problem. The design of a high-speed inspection system based on the machine vision method has been an interesting issue. The main advantages of optical inspection methods are their ability to scan large areas, their applicability to in-process measurement, and their ability to perform fast measurements [1]. Advances in manufacturing automation have created the need to develop in-process measurement techniques for online quality control and online machining compensation [2]. Most component manufacturing cycles include an inspection stage to ensure agreement with design requirements [3]. Automated visual inspection is also rapidly becoming a major factor in manufacturing [4]. Non-contact measurement is also favored since high-speed measurements can be achieved and problem associated with vibration and friction can be eliminated.

This paper researches on robot vision system to detect defects of the cover of crystal oscillators. The component of the robot vision system is given and discussed first. Then the customized wavelet transforms is presented for detecting the edge of acquired images in this paper. Through calculating the defect area of the image, the defects defecting is achieved. So the automatization manufacture is realized.

2 Component of the detecting system

The main components of the machine vision used in this work is made up by computer, CCD Camera, image collection clip and process software, light Source、engine and control part, as shown in Fig.1. Each component plays a vital role in the quality of detecting system.

(1) PC and software: This component controls collecting the image, communicating, attempering the resource, processing the image and fulfills the detection.

(2) Facility for colleting the image: This component collects the images of the cover of crystal oscillators. These contacts with the cover of crystal oscillators.

(3) Light resource: This component is a vital component to this system. One good light resource can diminish the complexity and improve the precision of detection.

Because this detection system demands the image processing cell have the exact result, the light resource must meet the requirement of providing the steady image input for a long time. The LED has lots of advantages according with the vision system’s need, so LED is selected as the light resource of this system.

Because the CCD in industry field is sensitivity to red light, and the image is clarity under the red light than other light, the red LED is selected as the light resource.

(4) Control part: This component fulfils the whole control work, accepts the detection result and inspects the station of the system. According the current station, the image is acquired or not decided by the software. At the same time, the software controls the action of the executing machine.

(5) Machine part: This component fulfils the adjustment of CCD and light resource, which make the system have the best image. At one time, it must assistant the control cell and executing cell completes their action.

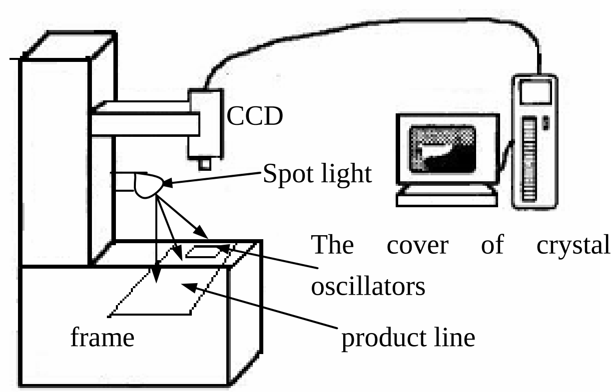


Figure 1 : The components of the machine vision

3 Analyzing the acquired images by the program developed in this paper

The cover of crystal oscillators has three type defects in product line, which are breakage, scratch and flex crack.

The flowchart of the program is shown in Figure 2. If the cover of crystal oscillator is broken, the brightness of the broken region is different from other regions. So we can extract the broken regions by calculating blobs. First calculate blobs of acquired images, if there are some broken regions, the number of blobs are calculated and return 0, otherwise 1. If the result is 0, turn on the yellow status light, which express the product is bad, then end the program; otherwise go to the next detecting step that is detecting the flex crack. If the result is bad, end the program; otherwise go to the next step that is detecting scratches. If the result is bad, end the program; otherwise turn on the green status light, which express the product is bad, then end the program. If the system occurs errors, turn on the red status light. Figure 3 shows the two classic types of defects of covers of crystal oscillators.

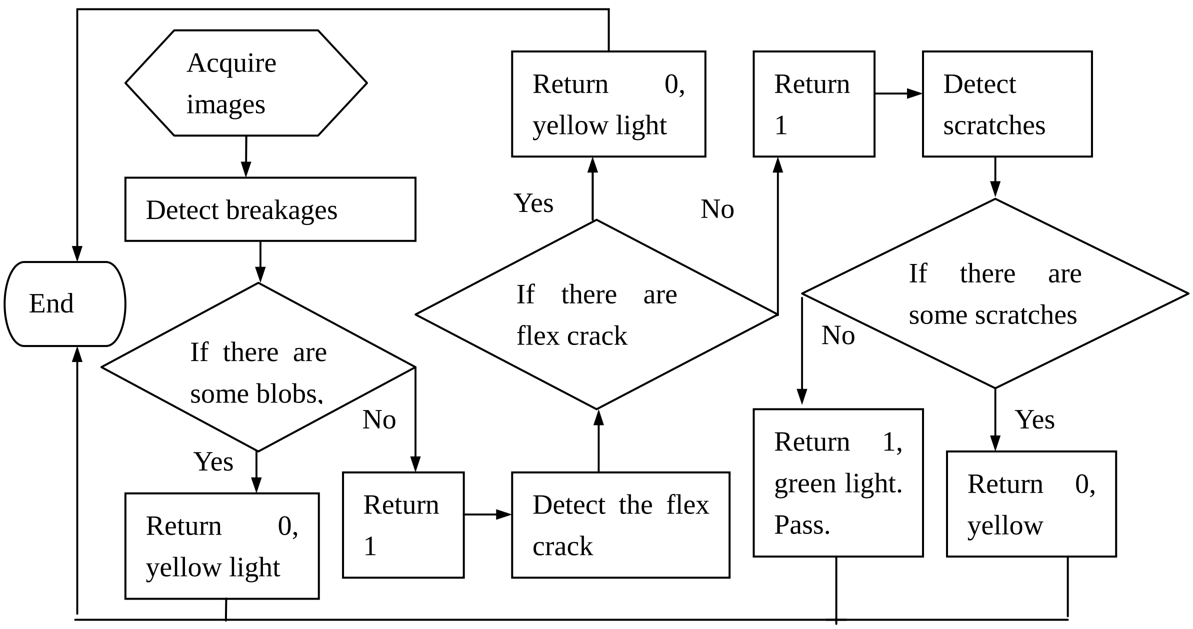


Figure 2 : The flowchart of the program

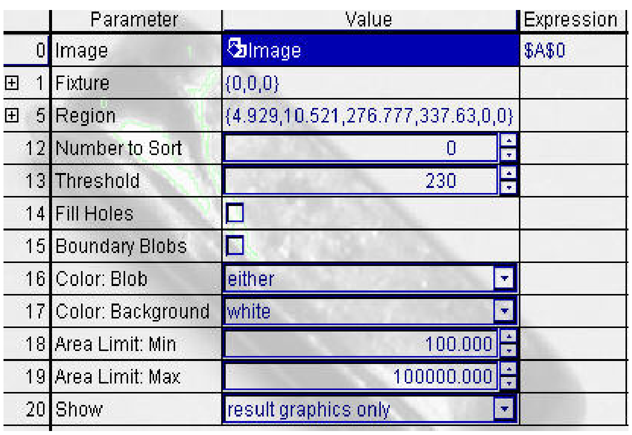
(a) The broken cover (b) The flex cracked cover

Figure 3 : The two classic types of defects of shells of crystal oscillators.

4 Image processing and detecting

As above-mentioned, the breakage of the cover of crystal oscillators could be detected by means of calculating blobs of acquired images. The parameters of extract blobs are shown as Figure 4.

If the cover of crystal oscillator hasn't been flex cracked, the distance of the first detected edge line to the last detected edge line is zero. That is to say they are parallel lines. So the flex crack of covers of crystal oscillator could be detected by means of measure the parallelism of lines. 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.



	Parameter	Value	Expression
0	Image	Image	A0
⊞ 1	Fixture	{0,0,0}	
⊞ 5	Region	{4.929,10.521,276.777,337.63,0,0}	
12	Number to Sort	0	
13	Threshold	230	
14	Fill Holes	☐	
15	Boundary Blobs	☐	
16	Color: Blob	either	
17	Color: Background	white	
18	Area Limit: Min	100.000	
19	Area Limit: Max	100000.000	
20	Show	result graphics only	

Figure 4 : The parameters of extract blobs.

A function $\psi(x)$ 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 $\theta(x)$.

$$\psi(x) = d\theta(x)/dx \tag{1}$$

Then

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

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.

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

$$\psi(x) = \begin{cases} 0 & |x| \geq 1 \\ -\psi(-x) & 0 \leq x \leq 1 \\ -24x^2 - 16x & 0.5 \leq x \leq 0 \\ 8(x+1)^2 & -1 \leq x \leq -0.5 \end{cases} \tag{4}$$

In the case of images, two wavelets $\psi^1(x,y)$ 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:

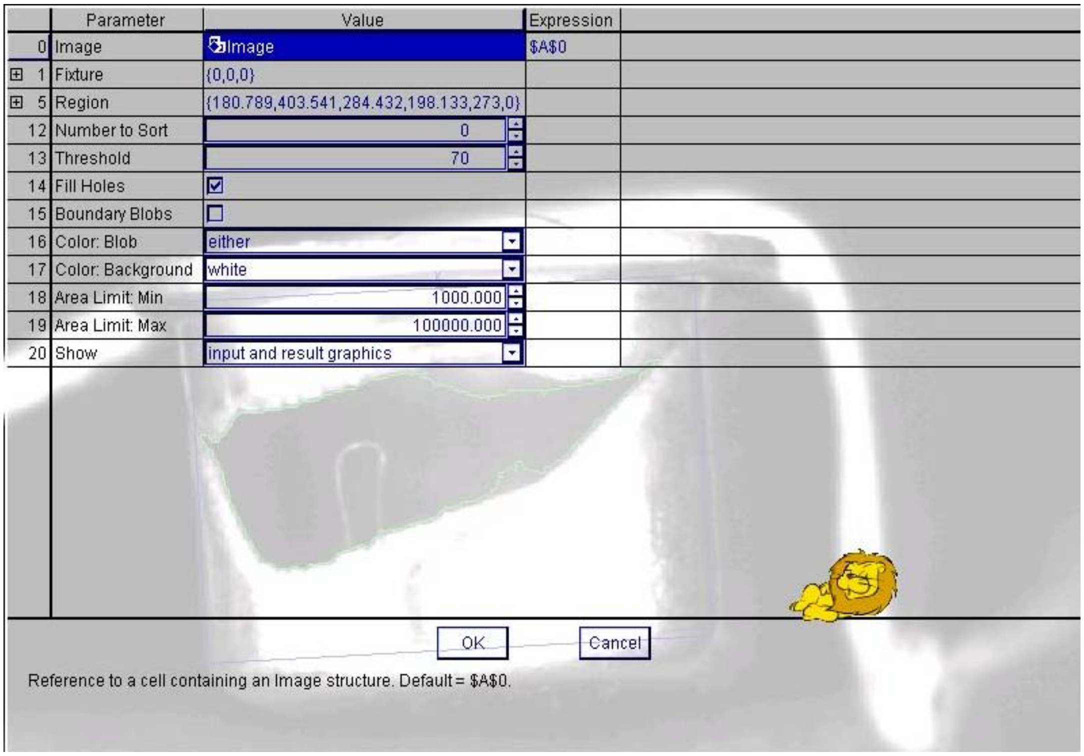
$$\psi^1(x,y) = \frac{\partial\theta(x,y)}{\partial(x)} \qquad \psi^2(x,y) = \frac{\partial\theta(x,y)}{\partial(y)} \tag{5}$$

Denote

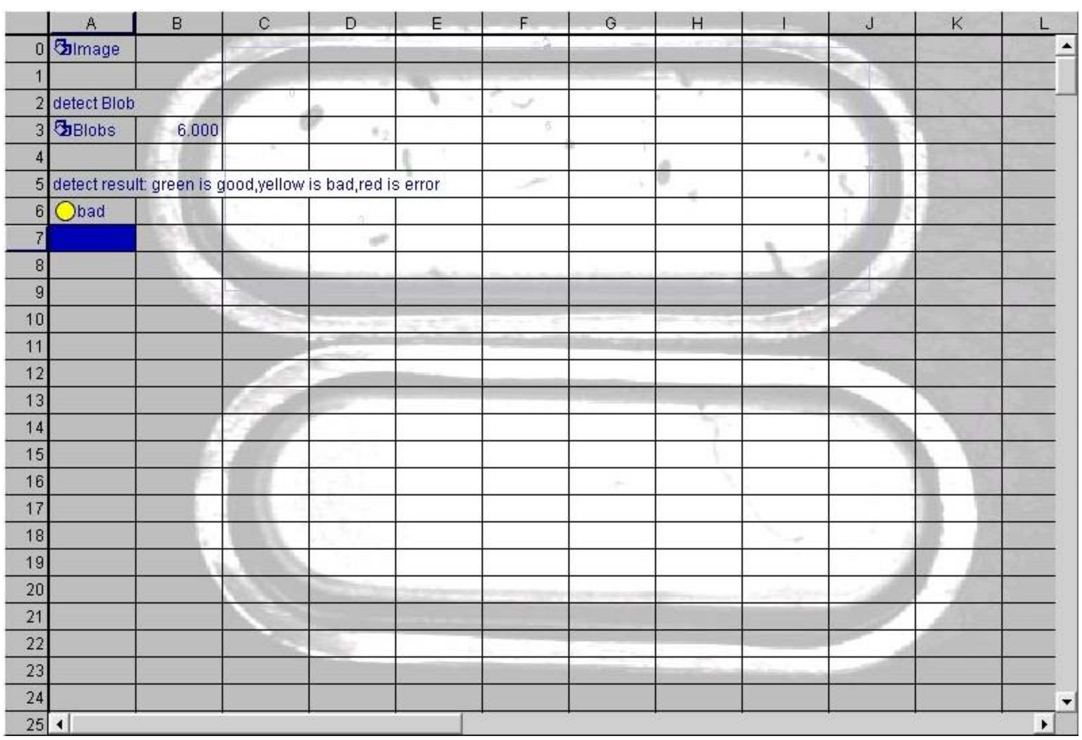
$$\zeta_j = 2^{-2j}\zeta(2^{-j}x, 2^{-j}y) \tag{6}$$

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 scratch could be detected by means of pattern match. The bottom image of good cover of crystal oscillator is defined firstly as a pattern, which saved in the memorizer. If the pattern matches the acquired image well, that is to say the product is good. Figure 5 only shows the detected results of the two classic types of defects.



(a) Blobs of the broken cover



(b)The parallel lines of bottom concave cover

Figure 5 : Detected results of the two classic types of defects

During the research on detecting the defects, we selected 200 frames images in two kinds of defects, including bottom concave and broken cove. The detecting result is shown in Table 1.

Table 1: The detecting result of two kinds of defects

Type / Index	Detecting of the bottom concave	Detecting of the broken cove
The ratio of detection	95%	90%

5 Conclusions

In this paper, the machine vision system for detecting defects of the cover of crystal oscillators is developed and the image processing algorithm of edge detection is proposed. The experimental results show that it could detect the two types of defects accurately and quickly. This system makes the manufacture of covers of crystal oscillators lower cost. According the quality of the cover of crystal oscillators, the station of machine can be judged. When the mould is braded greatly, punch can be turned off at once. The automation manufacture is realized. For detecting the border dilapidation, the probability is lower because the image is affected by the light source easily. So in order to improve the detection probability, the light source is more important.

References

[1] A. Abuazza, D. Brabazon, M.A. El-Baradie, Analysis of surface defects using a novel developed fiber-optics laser scanning system, Journal of Materials Processing Technology, 2003,143–144 :875–879.

[2] A. Abuazza, D. Brabazon, M.A. El-Baradie, Multi-beam fibre-optic laser scanning system for surface defect recognition, Journal of Materials Processing Technology, 2004, 155–156 :2065–2070.

[3] Byoung Chul Kim, Young Han Kim, Jeong Seb Han, A low-cost thermographic device for the detection of concealed groove in metal plate, Sensors and Actuators, 2005,A 118: 248–253

[4] D.M. Tsai, C.Y. Hsieh, automated surface inspection for directional textures, Image Vision Comput. , 1999, 18:49–64.