Design of Gear Defect Detection System Based on Machine Vision

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Abstract. In order to solve such problems as low efficiency, low quality and instability of gear surface defect detection, we designed a detection system based on machine vision, sensor coupling. By multisensory coupling, and then CCD camera image collection of gear products, using VS2010 to cooperate with Halcon library for a series of analysis and processing of images. At last, the results are fed back to the control end, and the rejected device is removed to the collecting box. The system has successfully identified defective gear. The test results show that this system can identify and eliminate the defects gear quickly and efficiently. It has reached the requirement of gear product defect detection line automation and has a certain application value.

1. Introduction

In recent years, with the rapid development of equipment manufacturing in China, the quality requirements for metal parts used in manufacturing and machinery are also becoming higher and higher. As an indispensable metal part in mechanical transmission and mechanical field, gears are widely used in mechanical transmission and whole machinery field. Gear detection technology is of great significance to the mechanical industry. [1] The testing technology of the surface quality and precision of the development gear is the necessary condition for improving the quality of the gear product. [2] According to different gears and different functions, there are defects such as collapse angle, lack of teeth, adhesive powder and crooked teeth, and the detection method is different. Traditional manual detection is time-consuming and laborious, and can cause visual fatigue. Conventional measuring equipment such as the three-coordinate measuring machine and gear integrated error detector are complicated and expensive. Because of the geometrical shape of the gear itself, the measurement process of tooth collapse, lack of teeth and crooked teeth is complicated, and the requirements of the tester are high. [3] The traditional gear measuring instrument structure is relatively complex, expensive, high technical requirements, general enterprise only by eye under the microscope distinguish them one by one, the efficiency and precision is extremely low, thus restricting its application to a great extent. [4] After decades of development, machine vision has become more and more widely used in robot vision, aerial mapping, anti-demand engineering, medical imaging and industrial testing. [5-6] For high speed automatic production lines, using machine vision method,
through access to detecting object image quality detection, and machine vision system has simple structure, easy to move, quick and advantages, such as data acquisition, required by the visual sensor module is relatively simple.[7] Computer vision technology, as a new non-destructive testing method, gradually become one of the effective methods to realize product quality control and fault diagnosis, and shows great vitality in gear measurement technology.[8-10].

Therefore, a gear defect detection system based on machine vision and multi-sensor fusion is designed. Through multi-sensor fusion, the visual system image collection of gear products, and carry out a series of mathematical morphological analysis, and the feedback the result in the control end. After removing the disqualified products to the collecting box, the fast recognition detection of the defective gear is realized.

2. System hardware design
As shown in figure 1, the whole system consists of four parts: multi-sensor module, conveyor belt device, stripping device and visual system. Multi-sensor module includes trigger board sensor, CCD camera sensor, infrared range sensor. After the trigger plate sensor is triggered, the image acquisition sensor is triggered, and the device is removed with the trigger of the range sensor. The time interval of gear detection can be adjusted by adjusting the speed of conveyor belt. The camera in the visual system continuously obtains the product image information and transfers it to the control terminal, ensuring the qualified rate of the test and the stability of the system. The infrared ranging sensor recorded and transmitted the digital signal to the control terminal in real time and controlled the elimination device to eliminate the unqualified products automatically, which ensured the high automation of the system.

![Fig. 1 The overall structure of the system](image)

3. System software framework design

3.1. software framework design
The system software processing flow is shown in figure 2, mainly including sensor module, image acquisition and processing module, control end and stripping device. After the fiber CCD sensor is triggered, the camera begins to acquire the gear image, process the image captured by the camera and convert the image information to digital image information. After a series of mathematical morphological treatments, the results are fed back to the control end. The removal device will remove defective gear and keep gears with no defects.
3.2. multi-sensor coupling

In the production line of gear product testing, it is an important index for the performance of the detection system whether the detection system can be efficient and accurate can be detected and removed. Multi-sensor fusion not only guarantees the accuracy of system detection, but also makes the detection more intelligent, realizing the automation and intelligence of gear production line detection. The selection and parameters of each sensor are shown below:

| Name            | model       | parameter                |
|-----------------|-------------|--------------------------|
| Optical fiber sensor | FSS2231DS  | FC/PC, ±1000,1%F. S      |
| CCD sensor      | GM133M-H    | 1280x1024, GIGE, C/ CS   |
| Ranging sensor  | FT80RLA     | 4-20mA, 250～750mm       |
| ZIG BEE         | QAZ2000     | 3.3 V 1600 m             |

4. System software interface design

The software interface runs on the PC control machine and adopt VS development environment for system development. Through the software interface, the detection template can be established, and the detection parameters are set. We can obtain the gear product image by multi-sensor fusion and visual CCD camera, so as to carry out real-time processing. The result of the treatment is fed back to the control end, and the rejected product is removed to the collecting box.
5. Test and analysis
In actual production, gear product quality defect detection is a crucial link. How to quickly and accurately identify defective gear products and remove them is the key to improve the efficiency of gear testing. The gear defect detection system based on machine vision is used to obtain the gear product image through multi-sensor fusion technology. After processing and analysis, the defective gear products are removed, and the automatic detection line is realized. In this paper, the gear defect detection system is used to detect the gear defect recognition test when the conveyor belt speed is 0.5m/s, as shown in figure 6.

Table 2. Gear defect detection test data

| Times | Width/mm | Sensor | Actual time/s | Theoretical time/s | Error |
|-------|----------|--------|---------------|-------------------|-------|
| 1     | Edge chipping | No     | 1.2           | 1                 | 0.2   |
| 2     | Edge chipping | No     | 1.3           | 1                 | 0.3   |
| 3     | Edge chipping | No     | 1.2           | 1                 | 0.2   |
| 1     | Sticky powder | No     | 1.4           | 1                 | 0.4   |
| 2     | Sticky powder | No     | 1.2           | 1                 | 0.2   |
| 3     | Sticky powder | No     | 1.3           | 1                 | 0.3   |
| 1     | Scratch     | No     | 1.4           | 1                 | 0.4   |
| 2     | Scratch     | No     | 1.5           | 1                 | 0.5   |
| 3     | Scratch     | No     | 1.4           | 1                 | 0.4   |
| 1     | Edge chipping | Yes   | 0.7           | 0.5               | 0.2   |
| 2     | Edge chipping | Yes   | 0.8           | 0.5               | 0.3   |
| 3     | Edge chipping | Yes   | 0.9           | 0.5               | 0.4   |
| 1     | Sticky powder | Yes   | 0.7           | 0.5               | 0.2   |
| 2     | Sticky powder | Yes   | 0.8           | 0.5               | 0.3   |
| 3     | Sticky powder | Yes   | 0.6           | 0.5               | 0.1   |
| 1     | Scratch     | Yes   | 0.9           | 0.5               | 0.4   |
| 2     | Scratch     | Yes   | 0.7           | 0.5               | 0.2   |
| 3     | Scratch     | Yes   | 0.8           | 0.5               | 0.3   |

It can be seen from the test results that when the system is in gear defect detection, the time error of multi-sensor coupling was significantly lower, and both were around 0.2 seconds, costing less time to identify the defective gears.
6. Conclusion

The design based on machine vision and multi-sensor fusion of gear defect detection system has better detection of defects such as gear breakdown, adhesion powder and surface scratches. The image information of the obtained gear is acquired and processed by the multi-sensor coupled vision system, and the processing results are transmitted to the control end, and the defective gear products are eliminated by the elimination device. Under the coupling of multi-sensor, the time error of detection system to detect the defects of gear collapse angle, adhesion powder and surface scratches was all within 0.2 seconds, within the margin of error. The test results show that the detection system has good performance of defect identification, such as broken angle, adhesion powder and surface scratches, meeting the requirements of automation of production line of gear production. The practical application of this product is of great value and the market prospect is wide.

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