Application of Computer-based Machine Vision Measurement System in Industrial On-line Detection

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Abstract. Computer vision detection technology is a kind of technology which can realize high precision detection. Computer vision technology is applied to image measurement system, which greatly improves the accuracy of image measurement and reduces the measurement error. The computer vision measurement uses the vision sensor to collect the target image, through the analysis processing to the image each kind of characteristic quantity, obtains the measured surface information.

Keywords: Computer Vision, Precision Measurement, Functional Characteristics, Image

1. Introduction
With the rapid development of science and technology, the instrument has begun to become more and more precise, which requires people to accurately measure the size of small parts, so as to guarantee the quality of the instrument.

But the traditional detection method is very difficult to achieve this. Later, people found that computer vision detection technology is a kind of technology that can realize high precision detection, so people began to apply computer vision technology to image measurement system. This paper mainly discusses the application of computer vision measurement system in industrial on-line detection, and takes a computer vision based tire load profile measurement system as an example. The measurement system consists of CMOS camera, laser sensor, grating ruler and controller. The three-dimensional space coordinate of tire side profile is used to reconstruct tire load side profile accurately, and its geometric parameters are measured quickly [1]. Computer vision technology has the characteristics of real time, precision and high automation, which is very suitable for the demand of industrial on-line image measurement system. Therefore, it is very necessary to use computer vision technology in image measurement system. Only by improving the accuracy of product detection can we better guarantee the quality of products and further develop our economy.

2. Brief introduction of computer vision technology
Compared with traditional detection methods, computer vision technology is more rapid, flexible and accurate. This is because computer vision technology is a modern detection method which organically combines computer graphics, information processing and other scientific technologies.

It can simultaneously realize picture acquisition and data analysis. For the edge part of the picture,
computer technology can accurately locate the position of the edge part, so as to collect accurate data. Therefore, computer vision technology can detect products more quickly, professionally and accurately. After many years of research, Chinese researchers have a deeper understanding of computer vision technology.

Computer vision technology mainly uses signal processing technology, probability statistical analysis and information processing technology in image processing, so that the speed of processing images can be greatly improved. For example, in face recognition, print or handwritten document recognition and vehicle recognition, this requires the measurement system to accurately handle the relationship between light, background and target, so that the nature of the image can be more accurately identified. At present, computer vision technology has been gradually used in various fields to improve the intelligence and automation of equipment. That can make the automation level of production of enterprise is able to rapidly increase, the quality of the products have been greatly improved, these will inevitably make the enterprise production efficiency greatly and promote the development of enterprises.

3. Principle and composition of computer vision measurement system

Computer vision measurement is mainly divided into three types: single visual method, stereo parallax method and structured light vision method. Computer vision measurement in tire profile measurement is a method of tracking, identifying and measuring targets using industrial cameras instead of human eyes. Compared with traditional methods, it has the advantages of non-contact, non-wear, high efficiency and high precision. Compared with other non-contact measurement methods, it has the advantages of simple principle, simple construction.

In computer vision measurement, the structured light vision method is a technique that uses both image and controllable light source to project structured light to the surface of the object under test. The camera collects diffuse reflection light of structured light on the surface of the object under test on one side. According to the geometric relationship of camera, structured light and object under test, the surface contour of the object under test is measured. It has the advantages of high precision, low cost and convenient use [2]. The operating principle of the system is shown in Figure 1. A precise displacement table is arranged on the tire side after compression and deformation, and a camera and a line laser sensor are placed on the displacement table. When the displacement table controls the camera to move to the appropriate depth of field, the line laser sensor is turned on. And at the same time to send the camera a trigger signal, the collected image signal through image acquisition card transmit to the computer. According to the principle of vision measurement is measured tire side contour point cloud.
4. Computer vision measurement software design

This study uses openCV as the underlying architecture to Visual C#.net write software interface. The system software includes four modules: camera displacement control, camera calibration, contour identification analysis and contour output.

4.1. Camera displacement control

The computer vision measurement system requires the camera position to have high repeated positioning accuracy.

MTS306 precision displacement table is driven by 42 step motor, and the camera is rigidly connected with the support surface of the displacement table. The stepper motor controller can realize the motion control of the camera, but it is difficult to realize the accurate control because of the drop characteristic of the stepping motor itself. As a result, a grating ruler is used as a feedback element with mm. resolution of 0.001. The grating ruler reading head is rigidly connected to the support surface of the displacement table, and the output displacement signal is uploaded to the computer by orthogonal encoder. A closed loop control system is formed by grating ruler, stepping motor controller, driver and orthogonal encoder [3]. The grating ruler feedbacks the read displacement information to the computer through the orthogonal encoder, the computer compares the feedback value with the ideal value, sends the correction instruction to the step motor control according to the displacement deviation. So that realize the motion closed loop control [5].

4.2. Camera calibration

In order to determine the corresponding relationship between the image coordinate system of the camera and the world coordinate system, the camera should be calibrated. The linear model formula of the camera is as follows:

\[
\begin{bmatrix}
    x_p \\
    y_p \\
    1
\end{bmatrix}
= \begin{bmatrix}
    K & R & T \\
    0 & 0 & 0
\end{bmatrix}
\begin{bmatrix}
    x_w \\
    y_w \\
    z_w \\
    1
\end{bmatrix}
\]

(1)
The linear model of the camera is obtained by substituting the coordinate correlation data of the following table 1.

**Table 1.** Coordinate data.

| Coordinate relations | Image coordinates | $x_p$ | $y_p$ |
|----------------------|-------------------|-------|-------|
| World coordinates    | $x_w$             | 0.5   | -5.7  |
|                      | $y_w$             | 2.3   | 1.8   |
|                      | $z_w$             | 14.5  | 8.3   |

4.3. **Profile identification analysis**

4.3.1. **Image processing**

When the image is acquired through the camera, the image will be disturbed by noise due to the influence of external interference and the electronic noise of the camera itself [6]. Therefore, noise reduction is carried out on the basis of image background removal to improve image quality.

Due to the influence of illumination and the limitation of hardware itself, the line laser fringes obtained by the camera are sometimes blurred, which affects the measurement accuracy, so the image must be enhanced. S curve enhancement algorithm is used in this work.

4.3.2. **Central line extraction**

In the visual measurement system, the extraction accuracy of the center of the light strip directly affects the measurement accuracy of the whole system.

Usually, the subpixel precision optical strip center extraction methods include geometric center method, center of gravity method and curve fitting method. Considering the robustness, computational efficiency and accuracy of the algorithm, curve fitting method is adopted. In the above measurement system, the general part of the component can only be photographed, but the clarity of some details that need to be paid attention to on the edge of the component is not high, which will greatly affect the accuracy of the measurement [4]. Therefore, as long as the accuracy of image edges can be improved, the accuracy of image measurement system can be greatly improved. Because the edge of the image has the feature of gray mutation, the edge point can be determined according to the gradient value of the pixel point, and the accuracy of the edge point determination can be strengthened by Sobel operator. Then, each edge point is connected to get a single pixel edge image, so that when the image is processed, people can process the image edge orderly according to the single pixel edge image, which greatly improves the speed of image edge processing.

4.4. **Contour output**

The point data is fitted by calling Bessel curve fitting tool.

After fitting, the test results of section profile are analyzed twice by AutoCAD software. Meanwhile, in order to determine the test results, the parameters such as horizontal axis height, section width and bead width of tire section profile are saved to the Excel report by com components. The main content of computer machine vision research is to identify and express the shape and position of objects, to restore the spatial structure of objects and to analyze their motion. In more than 20 years of research and development, computer machine vision has made outstanding efforts and contributions in these two aspects, not only has the ability to perceive three-dimensional environmental information,
but also can store, identify and understand the perceived information. Therefore, it is more and more widely used in engineering practice. Robot and intelligent manufacturing technology represent the development level of a country's manufacturing industry and have become the key development fields and industries of developed countries in the world. However, as an important part of industrial robot technology, the application technology has not been paid enough attention to, which affects the application and popularization of industrial robot, and restricts the large-scale development of industrial robot industry itself.

5. Summary
Machine vision is widely used, especially in industry and engineering.

In short, computer machine vision is the science of how to make machines "see" and the extension of human vision on machines. Computer vision integrates optical, mechanical, electronic, computer hardware and software technology, involving computer, image processing, pattern recognition, artificial intelligence, signal processing, optical, mechanical and electrical integration and other fields. With the help of deep learning algorithm, the performance of computer machine vision technology has made an important breakthrough, which has become one of the basic application technologies of artificial intelligence, and is a necessary means to realize automation and intelligence. In the automatic assembly line, the automatic assembly line is automatically controlled by a computer. It can automatically collect, process and feedback all kinds of information needed for processing and transportation process summary, and carry out hierarchical control over processing units and transmission equipment through industrial computers or other control devices. The automatic assembly line integrates high rigidity, high speed and high efficiency. Computer vision technology is applied to industrial on-line detection. Taking tire as an example, a method of measuring tire side profile based on computer vision is proposed. stepper motor driver, grating ruler and precision displacement table as motion unit; CMOS camera and image acquisition card as data acquisition unit[10]Write the corresponding measurement software and user interface. Compared with the traditional manual measurement method, this method has the advantages of non-contact, no wear and high efficiency. The whole measurement process takes short time, low intensity and high precision. Computer vision technology mainly uses signal processing technology, probability statistical analysis and information processing technology in image processing, so that the speed of processing images can be greatly improved. It can be seen that the computer machine vision measurement system plays an important role in industrial on-line detection.

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