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Research on Measurement of Mechanical Parts Based on Vision

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Abstract. This paper mainly elaborated the working principle of machine vision measurement system and the brief design of hardware structure. Firstly, the selection of CCD camera, image acquisition card, light source are explained basing on the specific method of camera calibration. Then the software used in image processing is introduced in the case whose hardware system design has been basically completed. The operating method of the software is described in conjunction with an example.

1. Introduction

The measurement of mechanical part dimensions has progressed rapidly in the field of mechanical manufacturing. Machine vision systems have the advantages of high precision, high timeliness, low cost, etc. When used in industrial product testing, the role played by the machine vision system cannot be underestimated. Due to the disadvantage of manual operations, manual measurements are slowly being eliminated by the society. The two modules implicated in hardware and software constitutes the whole of machine vision. The hardware part is mainly responsible for collecting images, while the software part is to process images in advance to determine the image size.

2. How Do Vision-Based Dimension Systems Work

Machine vision is widely used in various fieldsin the process of measuring the workpiece, because of its high precision, high efficiency, high automation and other advantages. The visual measurement system should follow the following process while using: reconstruct the 3D solid based on the 2D image captured by the CCD camera, read the real-time image, and calculate the feature information such as the position and size of the workpiece. The actual workpiece model can be constructed from the image by knowing the point in the image of the workpiece in the camera. The camera model is defined in the context of photographic geometry. The specific content is the mutual transformation between two-dimensional images and three-dimensional limbs. There are many parameters in the camera model. There are two kinds of parameters: camera parameters and camera parameters. The camera parameters represent their optical or geometric parameters, covering the focal length, principal point, distortion parameters, scale factors and so on. Camera external parameters are the position of the camera relative to the external world coordinate system, which is divided into translation and rotation parameters. The process to obtain the above parameters is the so-called calibration.

The operation steps of the system areplacing the workpiece under test on the stage first, and then moving the platform on the experimental device according to the position of the workpiece under the light source. The image processor can display and process the image. Then the image sensor will display. The analog image is passed to the image acquisition device comparing the difference between

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the actual value and the theoretical value, which has reached the previous requirements. The structure of the measurement system is shown in Figure 1.

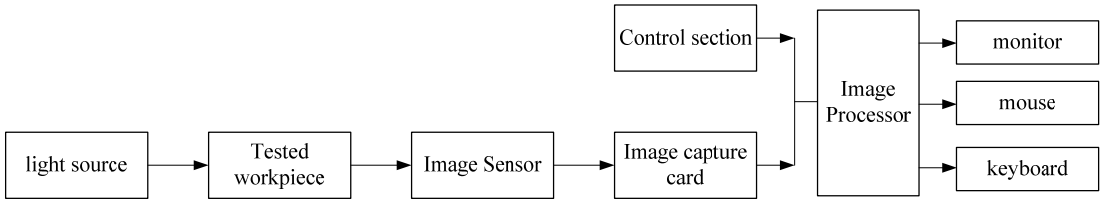


Figure 1. Measurement system structure

The structure of the system is roughly divided into three steps: image acquisition, image preprocessing, and product size measurement. The workpiece dimension measurement is divided into two modules: software and hardware. The hardware module is of critical importance in dimension measurement and is specifically responsible for image acquisition. The software part is responsible for image preprocessing and workpiece size determination.

The flow of the whole system is using the image sensor to obtain the image of the workpiece under test, saving the original image of the workpiece to a specific position in the PC, using the image processing software to perform a series of processing such as grayscale conversion and edge extraction of the workpiece image. Through the corresponding algorithm, people got the image measurement results. This measurement method is used because it can reduce the unnecessary damage of the workpiece during measurement, and truly achieves a contact-less measurement form.

3. Machine Vision Hardware Technology

There are three links in the visual hardware system: image acquisition, image preprocessing, and image display. The system can once again be divided into image capture links, optical modules, digital image processing parts, image digital transformation, regulatory enforcement, and intelligent decision-making modules among others.

The machine vision hardware system includes a lens, a light source, an image acquisition card, a CCD, and a computer. In the system, the light source provides sufficient illuminance for the system. The measured workpiece is captured on the target surface of the lens and transmitted to the CCD vision sensor. Then it was converted into an electrical signal through the vision sensor; the image acquisition card is responsible for transforming the electrical signal. Digital image information, that is, the brightness is converted into gray-scale data, and saved as a single or multiple images, computer to achieve image storage and processing, output measurement results and control signals.

The scope of application of machine vision systems is very large. In different applications, the same components cannot be selected, but each system consists of the most basic modules, namely the lens and camera, light source, image acquisition module and image processing software. In fact, the integrated image capture card and the camera have been integrated with each otherat this stage, and the two models have been separated from each other.

After being gradually transformed into past tense, the machine vision system is composed of backlight, front light, digital camera, computer and other components. The measurement procedure is roughly as follows: the workpiece to be tested is placed on the imaging table under the backlight; the CCD camera is used to perform image acquisition; then the image is preprocessed and the final processing result is displayed on the computer.

3.1. CCD and Lens Technology

Measurement systems usually use CCD as a visual sensor, which is based on large-scale silicon integrated circuit technology developed into a fitting integrated electronic chip that can convert optical signals into electrical signals. The analysis of the output information of the CCD is more convenient and easy to connect to the computer, thus constituting an online intelligent measurement system.

The lens is the part that gathers the light and gives the imaging module a high quality image. The high quality, low distortion and high price of the industrial lens make it mainly used in industrial parts detection and scientific research applications. While the lower image quality requirements and low cost application environment is suitable for the use of monitor-grade lens. Filters are also indispensable in lens technology.

With the electronic rangefinder focusing, the auto-focus camera can be automatically performed. In the process of capturing pictures, high-quality imaging of the target to be measured is performed. The focusing of the auto-focus camera can be performed in different ways. The active infrared system now has a wider application. Through the angle formed between the reflection and the light beam, the camera can use different algorithms to obtain the shooting distance, autofocus can be achieved. With this measure, an autofocus camera emits light from the body. Therefore, the brightness and contrast of the photographed workpiece cannot affect the focusing accuracy. Even in dark places where the light cannot be fully illuminated, it is possible to shoot smoothly. However, the principle of this method is that the infrared rays reflected from the workpiece and the angle of the original infrared rays are substituted into the calculation of the algorithm to obtain the desired data. Therefore, when the surface of the photographed workpiece cannot meet the requirement of reflecting light, the active infrared system cannot play its due role.

3.2. Light Source Technology

Light sources are crucial in computer vision systems. The main performance of the light source is to project the surface of the workpiece to be detected, highlight the characteristics of the place to be detected. Appropriate lighting can improve the overall effect of the system, making it easier to analyze the information later. Unmatched lighting will cause unnecessary interference to the computer vision measurement. For example, the excessive exposure caused by the camera's blooming point will cause the key information to be neglected. The appearance of the shadow will cause the edge to misreport. The difficulty in selecting image processing thresholds will continue to increase with reduced signal-to-noise ratio and lighting imbalance.

Therefore, the measurement of each workpiece requires different lighting measures. In some cases, several different measures will be selected to match. However, more appropriate lighting measures and optimal light source calls usually require a lot of tests to summarize.

The advantages and disadvantages of lighting conditions not only directly affect the quality of information transmission, but also determine the level of credibility and image processing effectiveness. Light sources cover the visible or invisible 2 categories. The visible light sources include incandescent lamps, fluorescent lamps, LEDs, and nano lamps. The advantages are low cost, easier access, and ease of operation. However, the light energy emitted by such light sources is not stable enough. Invisible light sources include X-rays, ultrasonics, etc. These types of light sources have very good accuracy when placed in a measurement environment. However, it is not convenient to use on-site operations. In addition to this, its cost is also high, which may lead to an increase in investment costs. Therefore, in the workpiece measurement process, visible light sources have a wide range of use. And most factories prefer to use thislight source. At present, no such light source device can appear in the circulation of purchases and sales to complete excellent measurement conclusions. So when in different operating situations, you need to carefully purchase matching light sources according to their unique needs. In addition, LED light sources have always been difficult to heat, high efficiency and low consumption, which do not take up the local and other benefits. Due to different research needs, we make a match between the conversion of the job to make the lighting show a format look.

Illumination includes of diffuse light irradiation, forward irradiation, back irradiation, and axial light irradiation. In the forward illumination, the light source and the shooting device need to be placed in the same direction that the workpiece needs to be detected, which is very favorable for on-site operations. The light source and the photographing device need to be placed one by one on the two different sides of the workpiece that need to be detected in the back-illumination. The images obtained

by such a method will have excellent contrast. In diffused light illumination, the light emitted from the light source system is reflected back by different light guides, thereby obtaining diffused light. This device can be arbitrarily converted to many different workpiece images to achieve the needs of the measurement system. The images thus obtained will have a good balance. The light produced by axial light irradiation is relatively bright, and it is very advantageous to monitor defects on a highly reflective material surface.

Table 1. Comparison of common light source performance.

Light Source Color Life (h) Brightness Cost Stability Remarks						
Tungsten halogen White, yellow3000-5000 Very bright Low Poor High energy consumption						
LED	Red, yellow, green, white	60000-100000	brighter	lower	better	Low energy consumption, small volume
Metal halide lamp	Warm and cold white	2000-20000	Very bright	higher	good	Low energy consumption, uniform color
Laser lamp	Single, depending on the active position of the laser source	Depends on luminescent substances	Extremely bright	Different in height	good	Good directionality, good monochromaticity, long range

The image obtained by back-illumination will have excellent contrast. The degree of contrast can immediately influence whether or not the edge scan is accurate. When mounting the backlight, the light source must be connected in the reverse direction of the workpiece to be tested. In the computer vision workpiece measurement system, such light source measures are used in a large number of applications. It is entirely possible to eliminate the possibility of ghosting while highlighting the edges of the workpiece to be measured.

The size measurement module is mainly responsible for measuring the size of parts, and obtaining accurate. A clear image is a prerequisite for measuring dimensions when we combine the different light source measures with the resulting image.

When the straight forward illumination mode is selected, the workpiece light source is unbalanced; when the background illumination scheme is adopted, the imaging is most clear and the contour of the edge is also very clear. When the scattered light illumination scheme is adopted, the imaging is not clear, so image processing is not suitable. So the best choice is the background lighting scheme. When performing a defect determination, a strong contrast is required to highlight the features of the defect, so it is most appropriate to choose a straightforward lighting solution.

This article uses a ring light source as shown in figures 2 and 3, which provides one of the main advantages of providing a large area of balanced lighting environments. When used in a real work environment, the ring illumination and the CCD lens must be coaxial on the same line as the lens edge. The main advantage of the ring lighting is that it can be installed without interference with the lens. The distance between the light source and the measured workpiece is relatively good, the probability of attenuated shadows appears with a high probability. The contrast of the image can be increased, and a wide range of fluorescence can be achieved. If the distance does not match, there will be reflections under the ring light source.

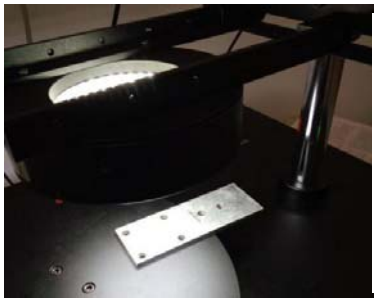



Figure 2. Ring light source real shot Figure 3 ring light source

Ring light sources have a very wide range of applications in circuit board applications because of their reputation for measuring good stains outside of highly reflective objects. The method has excellent effects on detection of printed characters on an IC chip, suppression of components on a circuit board, defects of workpieces on a production line, various product labels, which has been widely used.

As shown in Fig. 4, there are two types of light sources, namely, a point light source and a tunable light sourcein addition to the foreground light source, the background light source, the coaxial light sourcewhen the light source is selected.

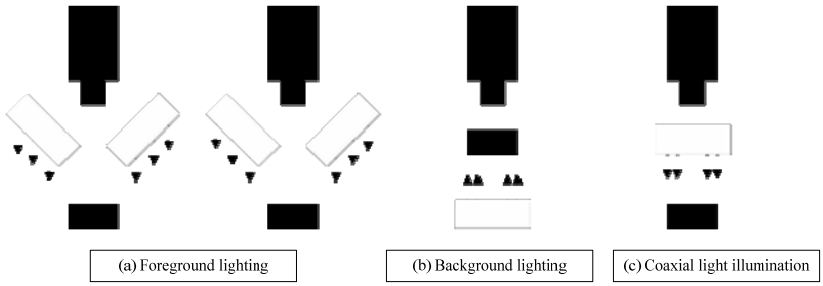


Figure 4. Three Light Sources

4. Image Capture Card

An image capture card is a type of electronic card that can be connected to a computer or used in addition to a computer, as a connected medium between image processing steps and image capture steps. The CCD camera provides analog information for this card, which is then converted to corresponding digital information using A/D. The above digital information is registered in the image storage space. When the computer issues a transmission statement, the registered original image information is transmitted to the storage space in the computer via the PCI path. In this way, the computer can analyze and calculate, which can also be displayed on the video card.

The general role of the image capture card in the vision system is to capture the image data sent by the camera in real time and provide an efficient interface to the computer. Usually, it is used as a bridge between the connection image acquisition device and the image preprocessing software. Since the image capture card needs to meet the user's need for real-time, on-line, high-quality data transmission when used in a vision system, the image capture card must possess additional types of performance in addition to the conventional A/D changeover function:

(1) The image capture card can restore the original image as it was by reconstructing the data information transmitted through the camera through multiple channels.

(2) The data stream from the camera is efficiently received via the computer bus and stored in the storage mechanism of the system.

(3) It has been used to general control other visual modules in the system such as lighting equipment and so on. When considering the image capture card, you must first match the type of

camera model, at the same time thinking can match the computer port. When continuously collecting images, it is necessary to provide relatively empty storage space for registration. At the moment when considering imagecapture cards, it is necessary to be cautious because it does not necessarily have the ability to compress. There is no need to obtain a lot of image information to measure when you propose measurement measures. Therefore, the best choice is an image capture card that does not have a compression function; it can be more convenient and available. The scope of the image capture card usually covers the following:

(1) Image format: Gray and other color are usually the basic units that make up the image format. There are usually more than 250 levels of grey levels in an image, half of which are expressed by eight bits. When the gray level of the image must be highly accurate,
Ten, twelve, and sixteen are used to express. The color image is mainly formed by matching the three colors of RGB.

(2) Resolution: The maximum value of the dot matrix that can be achieved by the image acquisition card shows the advantages and disadvantages of its recognition ability.

(3) Sampling frequency: This parameter represents the efficiency of the resolution of the image itself.

(4) Image transfer format: This board must be able to recognize the data format sent by the CCD camera in the measurement system.

(5) Camera Interface: The IEEE1394, USB, etc. connection data ports are commonly used in cameras. The camera's output interface must match the image acquisition card configured in the system. This article selects the commonly used CameraLink data channel to match the camera, so the selected image capture card should be well adapted to the CameraLink interface to achieve the normal working level.

(6) Clock frequency: The operating frequency of the image capture card and the camera must be the same. When all parameters of the image acquisition card are decomposed in all directions, the measurement measures are based on the ADLINK production
RTV-24 series are the multi-path real-time video capture cards, which provide four different data channels: 0, 1, 2 and 3, four cameras are provided for connection. Each data channel can send 30 full frames of captured images per second, and can even provide black and white or color options, as shown in Figure 5 below.



Figure 5. Image capture card

5. Summary

This article mainly elaborated the working principle of the machine vision measurement system and the brief design of the hardware structure. Based on the traditional measurement principle, a set of workpiece measurement system based on machine vision is designed. The design principle and composition of the workpiece are explained in detail, and the image processing algorithm is provided with hardware support.

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