Research on Automatic Inspection System of Printed Circuit Board Based on Computer Vision

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Abstract. With the development of computers and software, all walks of life are beginning to use computers and software to design systems, for example, the printing industry. Through computer technology, it designs an automatic monitoring system to simplify printing work. This paper mainly determines the general plan of the automatic monitoring system, it also analyses the related design of image acquisition control system and image detection control system.

1. Introduction
After years of development, the application of printed circuit boards has been very mature, which greatly improves our country's printing level. The automatic detection system uses various detection instruments to measure, indicate and record the main process parameters, it replaces operators to observe and record the process parameters, so it plays the role of the human eyes[1].

2. Determine the overall scheme of the system
2.1. The guiding ideology of system design
With the advancement of modern science and technology, society is developing in the direction of multi-discipline, multi-field, and complex integration. All kinds of information are intertwined and closely related. A complete and sophisticated intelligence. The detection system does not rely solely on a certain It may involve many fields and many aspects. It is a complex of many technologies. Just like the automatic detection system of printed circuit board defects studied in this topic, it involves precision Machinery, electronics, optics, image processing, computer vision, automatic control, microprocessors and other fields[2]. It is a high-tech product integrating optical and mechanical integration of computer vision technology, image processing technology, CNC precise positioning technology and automatic control technology. In particular, advanced computer technology has played an irreplaceable role in the design and application of automatic detection systems. The design of this topic is based on the rapid development of computer technology. For a detection system, its design should follow the following principles:

A. Requirements for measurement accuracy For an automatic inspection system for inspection purposes, inspection accuracy is the most important thing. Without accuracy, other designs will be impossible. The design of this subject is to replace the manual detection of PCB, so the detection accuracy of the system must reach the detection accuracy of the human eye.

B. Requirement of detection speed Speed is a very important aspect of a detection system. One of the main purposes of this system design is to increase the detection speed of printed circuit boards. Generally, the efficiency of manual detection is low and the speed is too slow. After the automatic
detection system is adopted, the speed should be obvious. Therefore, in the entire inspection process, how to adopt a reasonable plan will have a great impact on the speed of the system. Among them, the customization of the automatic image collection and splicing part and the image processing part of the plan will affect the system detection speed. The impact is particularly obvious[3].

C. Economic requirements In modern industrial systems, economy is also a main indicator to measure the pros and cons of the system. After weighing the requirements of accuracy, efficiency and economy, the system finally determined the hardware design plan to improve the system cost performance as much as possible. In this way, if the product is put into production, it will have a great market competitiveness.

2.2. System overall scheme design
The automatic detection system of printed circuit board defects [A0I] is mainly composed of several parts: lighting system, image acquisition control system, image acquisition system, image processing system, back-end database system, and error analysis system. As shown in Figure 1. Shown.

![Figure 1. The main composition block diagram of the system](image)

The lighting system is a very important part of the automatic detection system. Its main task is to produce suitable lighting and determine the accurate positional relationship of the object to ensure that the falling image with sufficient contrast and clarity is obtained[4]. The image acquisition control system is composed of precision The two-dimensional workbench, the lower computer workbench controller, and the upper computer computer system are mainly responsible for the collection of the image of the inspected object, the bidirectional movement and precise positioning of the two-dimensional work platform. The image acquisition and splicing system is composed of image sensors and image acquisition. It is mainly responsible for the image acquisition of the inspected object. Then it is input into the computer system for storage, and then the collected framed images are stitched into a complete image, which is convenient for subsequent image processing software. To process.

The image processing system mainly uses digital image processing algorithms to perform necessary image preprocessing and image segmentation on the inspected object, and adopts appropriate algorithms according to the target object to be inspected to detect defects in the inspected object. Back-end database management system: It mainly uses advanced database technology to realize scientific management of the detection of printed circuit boards. Error analysis and processing system: It mainly analyzes the factors that affect the accuracy and detection speed of the system and finds out the corresponding The solution is to reduce the error of the system and improve the accuracy and detection speed of the system. The concrete hardware structure of the system is shown as in Fig. 2. The system consists of a two-dimensional precision work platform, stepper motor, stepper motor driver, stepper motor controller, camera, image capture card, computer system (including image splicing system, image processing system, motion control system), display, etc. Component composition[5].
The working principle of the system is based on a precise two-dimensional workbench, supplemented by a CCD camera, a stepping motor, a dedicated motor driver, and a controller, to construct an automatic control platform for image acquisition on a printed circuit board, which realizes the precise two-dimensional workbench Positioning, complete the automatic collection of images, and communicate with the host computer in real-time through the serial communication port for information transmission and interaction. There are three control modes: manual, single-chip control and computer control.

The upper computer uses PC as the processor and VC++6.0 as the development tool platform to realize real-time communication, online control of image positioning, and use digital image processing technology to build a printed circuit board image processing expert system platform, image acquisition, and image Stitching, intelligent image processing, analysis and detection of defects, and finally input the defect information into the database for management and archiving.

3. Design of image acquisition control system
The main tasks of the PCB image automatic acquisition system are: before the PCB image acquisition, according to the relevant parameters set by the user, such as the size of the printed circuit board, the size of the camera's field of view, the time used for image acquisition, the direction of the workbench movement, and the It can wait to calculate the vertical and horizontal displacement of the worktable, the number of image acquisitions and the motion curve of the worktable in the process of image acquisition[6]. Then, the single-chip microcomputer outputs the control quantity according to these parameters, controls the speed and displacement of the movement of the worktable, and communicates with the upper computer in real time at the same time, and cooperates to complete the automatic collection task of PCB images.

3.1. The hardware design of the control system of the image acquisition work platform
The core of the PCB image automatic acquisition and control system is the two-dimensional work platform. To capture the PCB image by frame, the vertical and horizontal movement of the two-dimensional work platform must be controlled. In this system, a high-performance single-chip microcomputer from ATMEL is selected. AT89C52 to control it. AT89C52 is a low-power, high-performance microcontroller with 8KB of programmable and erasable memory on-chip. It integrates 8-bit CPU and EEPROM technology that can perform multiple functions on a single chip. The control application provides a very flexible and affordable solution[7]. Its main performance and features are as follows:

(1) Fully compatible with MCS-51 microcontroller products;
(2) On-chip contains 8KB of programmable/erasable memory (FLash Memory);
(3) 256 bytes of internal RAM;
(4) Two 16-bit programmable timer/counters;
(5) The interrupt structure has 5 interrupt sources, 2 priority levels,
(6) Programmable full-duplex serial channel;
The control system structure of the image acquisition work platform based on AT89C52 is shown in Figure 3.

![Figure 3. The structure diagram of the control system of the image acquisition work platform](image)

3.2. Anti-interference technology of image acquisition work platform system
Reliability is an important performance index of the SCM application system, which is determined by many factors. Among them, the interference signal is the main factor affecting the reliability. There are many sources of interference: the interference of the electromagnetic field of the power grid, the interference of the input and output channels, and so on. Interference will affect the correctness of the transmitted information, disrupt the normal operation of the program, and may even damage the hardware of the system. There are two main ways to solve the interference problem: one is to cut off the interference channel or reduce the impact of interference; the other is to enhance the anti-interference ability of the system itself. The specific methods include hardware anti-interference and software anti-interference. In terms of hardware anti-interference, mainly adopted: photoelectric isolation technology for input and output channels, power supply voltage regulation and noise removal technology, and anti-interference in the design of printed circuit boards design[8].

3.3. Software design of control system for image acquisition work platform
1) Main program flow
The image acquisition work platform control system is the core of the entire control system, and its program design is very important. During image acquisition, it has to process the modification of the image acquisition control parameters by key input, display it on the LED, and receive it. The upper computer transmits the control commands through serial communication, and carries out the corresponding movement according to these commands. The overall program flow chart is shown in Figure 3-10. In order to improve the execution efficiency and compactness of the code, all program codes are written in MCS-51 assembly language. In the whole program, the control program of stepping motor acceleration and deceleration is the most critical part.

2) The acceleration and deceleration control program design of stepping motor
In a real-time control system, the frequency of the stepper motor is usually required to be as fast as possible, but if it is too fast, it may lose step or even stall, because the response frequency $f$ of the stepper motor is relatively low (100-250 steps)/Sec, therefore, how to solve the contradiction between fast and not losing step, this is the problem to be solved by stepper motor variable speed control technology.
4. Design of PCB image detection system

4.1. Lighting system design

The reason why computer vision can perceive complex external information is entirely because of the result of the light field transmission, and the lighting strategy affects the spread of the light field. The choice of target lighting strategy directly affects the clarity and brightness of the image. In vision applications that need to process and analyze the target image, it actually determines the real-time and accuracy of image processing. This is especially true in applications such as, visual positioning. Therefore, the design of a reasonable image lighting system is particularly important. It is an important part of the PCB board defect detection system. Its main function is to produce a high-contrast object image to distinguish the uneven and fine structure of the wire. Traditional lighting sources include incandescent lamps, parallel light sources, infrared light sources, and lasers. Commonly used instruments for geometric measurement, such as length measuring machines, universal tool microscopes, collimators, etc., use cheap incandescent lamps. According to the positional relationship between the light source, the target and the CCD sensor, the lighting methods of the light source are divided into front-illuminated, back-illuminated, ortho-illuminated, oblique-illuminated, etc.

4.2. PCB image preprocessing

In the process of PCB image collection, acquisition and transmission, due to uneven illumination and the electronic interference of the CCD camera itself, noise is brought to varying degrees and the image is polluted. Noise sources include electronic noise, photon noise, speckle noise and quantization noise. If the signal-to-noise ratio (SNR) is lower than a certain level, the noise gradually turns into visible particle shapes, which will cause the degradation of the PCB image quality. In addition to the visual quality degradation, the noise may also cover up important PCB image details. The countermeasure adopted for this is to carry out the necessary denoising processing on the image, so the filtering of noise is a necessary preprocessing method, and the quality of denoising will directly affect the segmentation of the subsequent image and the recognition and judgment of image features. Therefore, the PCB image preprocessing is an indispensable part of this inspection system. There are many types of image noise filters. The more common filters include smoothing filters, low-pass filters, high-pass filters, median filters, morphological filters, etc. Based on this topic, the first two brothers Li Jinxi and Zheng On the basis of Wei, they have made a more detailed discussion on the filtering of image noise. The method used in this article is basically the same as that of them, and the method of median filtering is also used. I won’t go into too much here. Just briefly introduce the median filter. Median filtering is a nonlinear processing method to remove noise. It was proposed by Tukey in 1971. It was first used for time series analysis, and later used for image processing, and achieved good results in denoising restoration[9]. The median filter is an effective denoising filter, which can well maintain the edge details of the image while removing noise.

4.3. Software design of PCB image processing system

The image processing system software is a very important part of the printed circuit board image automatic inspection system. The design of this software directly affects the inspection effect of the system. In this topic, combined with the research results of the previous two seniors, a printed circuit board image inspection system software is designed. This system software is developed with VC++ 6.0 based on the Windows 2000 platform. It adopts a user-friendly interface and uses man-machine The function selection and operation are carried out interactively, and the software design adopts an object-oriented programming method, which constitutes a complete printed circuit board image processing system.
5. Further ideas for system improvement

5.1. Improved accuracy
(a) Image processing algorithm improvement. In this system, the image segmentation and image detection algorithm is a very important link. A segmentation algorithm with better segmentation quality and a better detection algorithm can be found to improve the detection accuracy of the system.

(b) Improvements in hardware. From the above error analysis, it can be known that the image stitching algorithm has a certain impact on the accuracy of image detection. This is mainly because there is an error when the single-chip microcomputer adopts an open-loop control system to control the movement of the worktable. Therefore, the photoelectric closed-loop control system composed of encoder or grating ruler can greatly improve the positioning accuracy of the worktable and reduce the image mosaic error[10].

5.2. Speed improvement
(a) Image processing algorithm improvement. Because every processing link in the system consumes time. It is possible to find an algorithm with better real-time performance and detection quality to improve the speed of image detection.

(b) Improvements in hardware. In the middle of this system, a CCB camera is used for image collection, so the speed of collection is relatively slow. Multiple CCBs can be used to work at the same time to collect images, which will greatly increase the speed of image collection. Large amount of data is a major feature of image data. Conventional software cannot be processed in time. If hardware is used for image processing, such as DSP, this will greatly increase the detection speed of the system.

6. Conclusion
This system has been successfully applied to printing plates, we have obtained good social and economic benefits through it. Although the system still has certain defects, I believe that when the computer technology becomes more mature, the system will be better and better, and its application in the printing industry will be more extensive.

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