

# Design of Automated Chip Inspection Platform

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## Abstract

Automated defect detection technology can effectively improve the production efficiency of manufacturing enterprises, and it is an important means and method for today's enterprises to realize industrial transformation and upgrading. This transformation is particularly important for the development of small and medium -sized enterprises in the field of industrial electronic equipment manufacturing. At present, defect detection based on machine vision is a popular research channel to realize automatic defect detection technology. This paper takes an ultra-thin gigabit single-port network transformer chip product as the carrier, and proposes a system study of automatic defect detection technology based on machine vision to remove and sort the defective chip products in the manufacturing process. This research focused on the development of an efficient, accurate and stable automatic defect detection platform for ultra-thin gigabit single-port network transformer chip products. In this regard, the research content of this paper mainly focuses on the four aspects of detection platform design, vision system setting, image analysis and processing, and control system realization.

## Keywords

PLC; Machine Vision; Defect Detection; Automation.

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## 1. Introduction

From the 1980s to the early 1990s, with the major changes in the global industry, the global demand for electronic components represented by the electronics industry increased sharply. According to statistics from the "World Electronic Data Yearbook", Lu Guoquan of the Institute of Electronic Information of the Ministry of Information Industry of China analyzed that in 2001, the world's total production and sales of electronic components were US\$109.859 billion and US\$106.712 billion. Among them, the total value of production and sales of electronic components in the Asia-Pacific region reached US\$31.491 billion and US\$30.386 billion, accounting for 28.75% and 28.53% of the world's total, successfully ranking first in the global demand for electronic components. [1-5]

Since the second half of 2016, my country's electronic information manufacturing industry has seen steady growth. According to statistics from the National Bureau of Statistics and the Ministry of Industry and Information Technology, the total profit of my country's electronic information manufacturing industry above designated size in 2018 was close to 500 billion yuan, and the total output value of its electronic information industry has ranked first in the world, and the market scale is huge. SMIC has become the world's fifth largest chip manufacturer in the field of integrated circuits, and Huawei has become the world's largest network and equipment operator in the field of communications equipment, the main business income of my country's electronic information manufacturing industry reached 4984.6 billion yuan, ranking first in the world [6-10].

At this stage, the global production and manufacturing of electronic components and the development of technical levels are constantly trending towards chip, miniaturization, composite, high-performance and high-precision directions. Among them, surface-mounted chip components

represented by network transformers are commonly used in electronic and electrical equipment in various industries. In the new round of industrial restructuring, the market demand for ultra-thin gigabit single-port network transformer chip products with ultra-thin, small, lightweight and high-efficiency innovation breakthroughs will continue to grow and be widely used [11-12].

The introduction of an automated inspection system is expected to solve the bottleneck limitation of this link, but there is currently no commercial product that can be directly used in China, and there are not many researches on the detection system for the multi-feature defect of the tiny size module. Aiming at the problem of low recognition rate of complex tile surface defects, Li Junhua and others proposed a multi-feature fusion algorithm based on BoF framework to classify tiles. Tang Wanyou and others adopted a method based on Blob analysis to visually identify the defects in the color and shape of the printed matter through template matching. Aiming at the size and defect detection of the seal ring, Li Shaohui and others proposed image processing research algorithms for contour extraction and tracking, offset probability matrix and offset second-order moments of the products to be inspected. The above algorithm can detect multi-feature defects in the plane image of a part, but under actual production conditions, a part needs to recognize many features, and a single detection algorithm cannot meet the needs of all features. Therefore, it is necessary to study a method that can automatically adjust the light. , Automatically realize the defect detection mode of multiple shooting and multiple judgments.

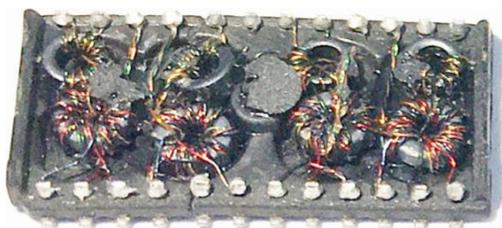
In this regard, this paper puts forward "Research on the Defect Detection System of Network Transformer Chip Products Based on Machine Vision" as the topic, aiming to improve the efficiency of multi-feature defect detection for micro-sized parts. This subject takes ultra-thin gigabit single-port network transformer chip products as the research object, uses machine vision technology to obtain real-time part images and extracts its defect characteristics, and combines automatic control technology for equipment development, and finally realizes automatic defect detection and detection of chip products. Fast rejection of unqualified chip products [13-15].

## 2. Research Object

### 2.1 Detection object

The thin gigabit single-port network transformer chip (also called network filter, data mercury, network network port module or isolated data network module) is a toroidal winding transformer represented by a ferrite core transformer. This chip product is mainly used for high-end gigabit routers, Internet of Vehicles, PCMCIA cards, computer network cards, micro network peripheral cards, security equipment and smart home appliances and other network communication instruments and equipment network ports. Its function mainly has the following three points:

- (1) Enhance the signal capability of the equipment to make the transmission distance of the equipment longer;
- (2) Enhance the equipment's anti-interference ability, and increase the equipment's external isolation protection (lightning protection, etc.);
- (3) When two network communication devices are connected because of different levels, neither of them will be damaged.



(a) Chip side view



(b) Scratches on the chip surface

Fig. 1 Transformer chip

### 3. Structure design of testing platform

#### 3.1 Overall structure plan

The detection control platform studied in this article mainly covers four aspects as shown in Figure 2, involving mechanical structure design and assembly, chip product image acquisition and analysis and processing, upper computer software control and programming development, and realization of chip product automatic rejection and sorting. Related research contents such as electrical control debugging of the detection platform.

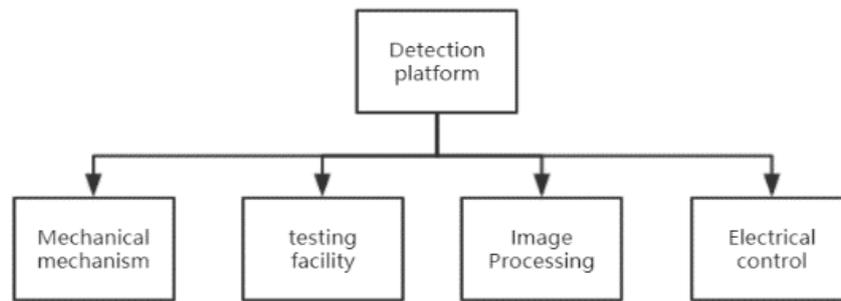


Fig. 2 Inspection process

#### 3.2 Overall structure design

In order to avoid assembly failures caused by individually designed parts and improve design work efficiency, the system testing platform adopts the reverse engineering method of drawing 3D drawings first and drawing 2D drawings through 3D model export for design and transfer. After the feasibility analysis and parameterized design of the detection platform scheme, the 3D detection platform model is established according to the proportion and structure. The parametric 3D modeling software Solidworks is the most widely used in the fields of design, engineering and manufacturing, so this time, the Solidworks 2016 version under Windows 7 environment is used to build the 3D model.

Through the selection of the testing platform structure scheme, the model construction and assembly of standard and non-standard parts, and the design principle of "total to detailed", the design and construction are based on factors such as function, quality, efficiency, and design cost. The 3D model inspection platform shown in Figure 2-3 has a length, width, and height of 1850 mm×470 mm×1590 mm. The overall design of the platform has an efficient and ingenious design. To put it simply, the overall structure model can be divided into three working areas: the upper part, the middle part and the lower part. The upper part is the delivery device table area, the middle part is the image defect detection area, and the lower part is the chip removal device area. . Among them, the upper part and the lower part of the working device table are inclined 45°, and the middle part of the image defect detection area is a horizontal design.

The chip product relies on gravity and the chute from the upper part to quickly reach the middle part. At the same time, through the PLC control system, the chip product is quickly and accurately pushed to the middle position of the backlight source and the industrial camera group. After a rapid detection of 100 ms, the chip product is again Pushed to the next part by the cylinder, experiments show that the inspection cycle of such a chip product can be guaranteed to be completed within 500 ms.

The push tube mechanism is filled with the plastic tube of the chip product to be inspected. After removing one end of the plug, it is stacked in the plastic slot in a longitudinal row. When the push tube cylinders at the two ends of the slot simultaneously push the connected plastic tube Pushing the plate, the plastic tube is pushed out, and the chip product slides down by gravity. When the photocoupler detects that the chip product has fallen down as an empty tube, the two push tube cylinders are retracted at the same time. At this time, the empty tube falls to the take-over bracket.

And the next plastic tube filled with chip products to be inspected is pushed out, and then it goes back and forth to provide a steady stream of products to be inspected. The two sets of pushing and tube mechanisms in the lower part have the same principle.

The chip product released through the tube pushing mechanism, if it is allowed to fall naturally by gravity, it is bound to be unable to collect images by the CCD camera. Therefore, a stopper mechanism is designed, which can realize intermittent and periodic slippage of chip products. The principle is as follows: cylinder is closed → the finger of the stopper is lifted → the first chip product is dropped down → the finger of the pressing piece (the end of the finger is soft material) is pressed down → the product next to the second chip is stationary → the cylinder opens → The finger of the stopper goes down → the finger of the presser is lifted → the second chip product is released → the second chip product is blocked by the finger of the stopper → the third chip product stays still → the cylinder opens. Repeat this way until it stops.

When the chip product passes the test, the product passes the small push cylinder I in the middle part and is directly pushed into the lower part of the qualified plastic tube; when the chip product fails the test, the stopper cylinder will immediately extend to block the chute, and the chip product will slide down to the slide In the tank, the dividing and pushing cylinder quickly pushes the dividing block, and when it is in place, the blocking cylinder returns, the chip product is released into the unqualified plastic tube, and the dividing and pushing cylinder is retracted, waiting for the next action.

Except that the box body is cold-rolled carbon steel (SPCC), the non-standard design parts of the inspection platform are all 6061 aluminum plates, covering a total of 46 sets of components and 110 non-standard design parts. The platform is completed by a large number of fastening connections. Hardware assembly. In addition to the design of non-standard parts, the hardware testing platform also has standard parts research and selection.

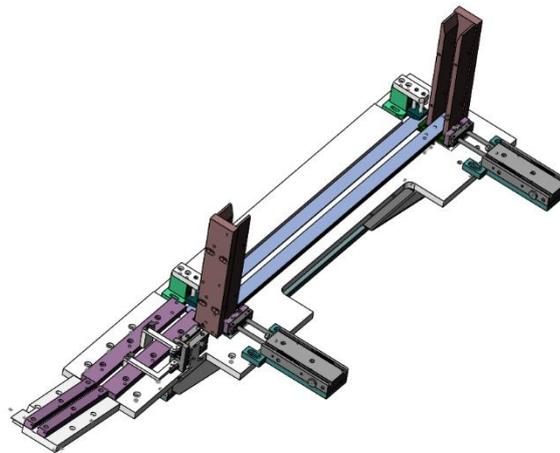


Fig. 3 The overall structure of the detection platform

### 3.3 Structure design of detection module

Machine vision first originated in 1951, when the famous American scientist John von Neumann used a computer to analyze two-dimensional images. Early research mainly started from pattern recognition, and the work was mainly focused on two-dimensional image analysis and processing. In the 1960s, when Dr. Robert J. Shillman of the United States studied the world of building blocks, he used image preprocessing, image edge detection, image contour matching and other technologies in image processing, began to study and analyze machine vision three-dimensional images, and created the world's first A machine vision inspection company for industrial cameras, and some visual motion systems have gradually appeared. At the same time, MIT's artificial intelligence (Artificial Intelligence) laboratory officially opened a "machine vision" course. In 1975, the concept of Computer Vision (CV) first appeared. In 1977, Professor David Marr of Massachusetts Institute of Technology put forward the machine vision theory, which has been greatly developed. The vision is divided into three layers

(that is, goal and strategy, representation and algorithm, hardware realization), and the theory is divided into three levels (Low, medium and high correspond to 2, 2.5, and 3 dimensional space respectively). From the 1980s to the 1990s, machine vision technology developed more rapidly. Due to the rise of the computer industry, the rise of the semiconductor industry, and now the 3C industry, it has led to the rise of the global automation industry. Machine vision has played an important role in the field of automation, and a wave of vision has emerged. Machine vision has begun to enter a period of great development, and various theories have emerged one after another, which promotes the advancement of science and technology and brings many conveniences to society.

This machine vision-based chip product defect detection control system includes two system parts: hardware system and software system. The hardware system includes machine vision hardware system and defect platform hardware control and removal mechanisms, such as PCs, digital controllers, and industrial camera sets (Camera and lens), light source, frame grabber, input and output port and position sensor and other important components. Among them, the digital controller has been selected for PLC brand and model, and the defect detection control platform and the rejection and screening mechanism design of chip products have also been completed. The following will focus on the selection and determination of industrial cameras, lenses and light sources.

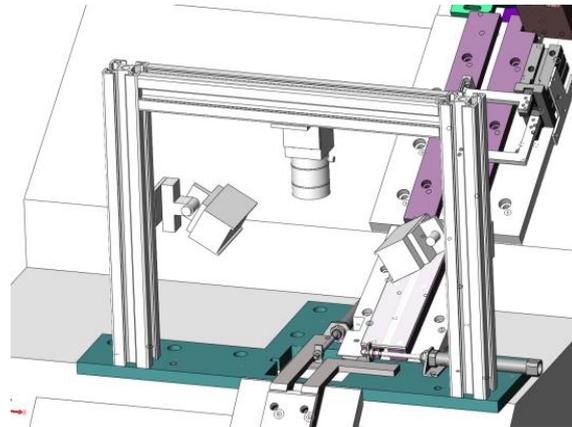


Fig. 4 Testing facility

## 4. Component selection

### 4.1 Control component selection

At present, the commonly used digital controllers mainly include PLC (programmable logic controller), MCU (microcontroller), ARM, DSP, CPLD, FPGA and other main controller types. Their roles and functions in the industry are different. But they are all popular types of digital controllers.

The overall requirements of the controller required for this defect detection system research are as follows: the programming is relatively simple; the control program is stable; the anti-interference ability is good; and the environmental adaptability is strong. Combined with the principle of the detection platform model designed by 3D modeling and analysis of the work flow, the required electrical control structure and quantity are not much, and they are all I/O port switch control. The principle is relatively simple, so choose the PLC indicated above reasonably. Programmable logic control is the main controller unit of the hardware system.

(1) In terms of use: PLC controllers are widely used in industrial production, processing and manufacturing due to their mature technology, strong versatility, easy use, wide adaptability, high reliability, strong anti-interference ability and relatively simple programming. , Transportation, infrastructure and other major fields, the application space of industrial control is particularly broad.

(2) Technical aspect: PLC controller is used for input, output and logic control, analog quantity control such as current, voltage, temperature and pressure, motion control such as machine tool displacement and point control, data acquisition, signal monitoring And network communication, etc.

(3) Brands: There are many brands of PLC controllers. There are well-known brands such as Mitsubishi, Omron, Siemens, Schneider, etc. abroad, and independent PLC brands represented by companies such as Hollysys, Delta, and Xinje have developed extremely rapidly.

In this defect detection system research, according to the number of input and output terminals and the control type of the control system detection platform, the cylinder switch is controlled. After research and comparison, the FX series MELSEC FX2n-32MR PLC controller of the Mitsubishi brand is selected. As shown in Figure 6



Fig. 5 Mitsubishi Melsec FX2N-32MR controller

#### 4.2 Cylinder and solenoid valve selection

The solenoid valve is an electronic component used to control the conduction and reversal of the compressed gas. Its installation position is between the compressor of the air source device and each executive cylinder, and it acts as a switch on the air pressure route. In this research, the hardware control platform design involves the use of 5 models, with a total of 11 cylinders in the upper, middle and lower parts. The push tube cylinders between the upper part and the lower part need to work in pairs at the same time. Therefore, the two cylinders of the upper part and the four cylinders of the lower part are divided into one group and two groups of cylinders respectively in the wiring control. Unicom. The working principle of the overall air circuit control is to use the internal sealed cavity and the electromagnetic coil to work together. When the PLC controller gives its electric signal, it can change the direction of the compressed gas inside the pneumatic actuator, thereby changing the working state of the cylinder. The selection of AirTAC two-position five-way solenoid valve is shown in Figure 6.



Fig. 6 The electromagnetic valve

### 4.3 Camera and lens selection

This machine vision-based chip product defect detection control system includes two system parts: hardware system and software system. The hardware system includes machine vision hardware system and defect platform hardware control removal mechanism, as shown in Figure for machine vision system Sketch. The figure contains the hardware modules required by a typical machine vision system, such as PCs, digital controllers, industrial camera sets (cameras and lenses), light sources, image capture cards, input and output ports, and position sensors. section. Among them, the digital controller has been selected for PLC brand and model, and the defect detection control platform and the rejection and screening mechanism design of chip products have also been completed. The following will focus on the selection and determination of industrial cameras, lenses and light sources. At present, with the development of various types of sensor chips on the market, the process of digital images has been accelerated. These sensor chips can directly acquire images, which brings great convenience to image processing. The hardware equipment of a machine vision system generally mainly includes industrial cameras, lenses, and light sources. Among them, industrial cameras are an important core part of machine vision systems and industrial inspection applications, which directly affect the quality of collected images. According to the camera chip type, there are two types of industrial cameras based on CCD (Charge Coupled Device) chips and CMOS (Complementary Metal Oxide Semiconductor) chips. Through many considerations, the camera chose the Medvision MV-GED500C-T CCD camera for image acquisition. The specific parameters of the camera are shown in Table 1. The lens chooses Medvision MV-LD-25-5M-E, and its specific parameters are shown in Table 2.

Table 1. MV-GED500C-T camera parameters

Project	Parameter
Sensor	2/3"CCD
Resolution	2448×2048
Exposure time range	0.005~1200000 ms
Pixel bit depth	12 bit
Sensitivity	530/800 mV 1/30 s
Frame rate	9FPS
Pixel size	3.45×3.45 μm
User-defined data area	2K Bytes
Frame buffer	32M Bytes
Vision Standard Agreement	GigE Vision V1.2, GenICam
Gain (multiple)	16
Visual agreement	GigE Vision, GenICam
Support language	C#/C++/C/VB6/VB.NET/Python
Dimensions	29 mm×29 mm×40 mm

Table 2. MV-LD-25-5M-E type lens parameters

Project	Parameter
Lens model	MV-LD-25-5M-E
Focal length <i>f</i>	25 mm
Aperture range	F1.4~F16
Interface	C
Minimum object distance	100 mm
Focus range	0.1 m-∞
Field of view	68.8 °×57.1 °×44.1 °
Back focus	12.69 mm
Filter size	M39×0.5 mm
Characteristic	5.0 MP
Physical dimension	Φ41*51.4 mm

## 5. Software programming

### 5.1 Automatic control process

The automatic detection process of the automatic detection platform is shown in Figure 7.

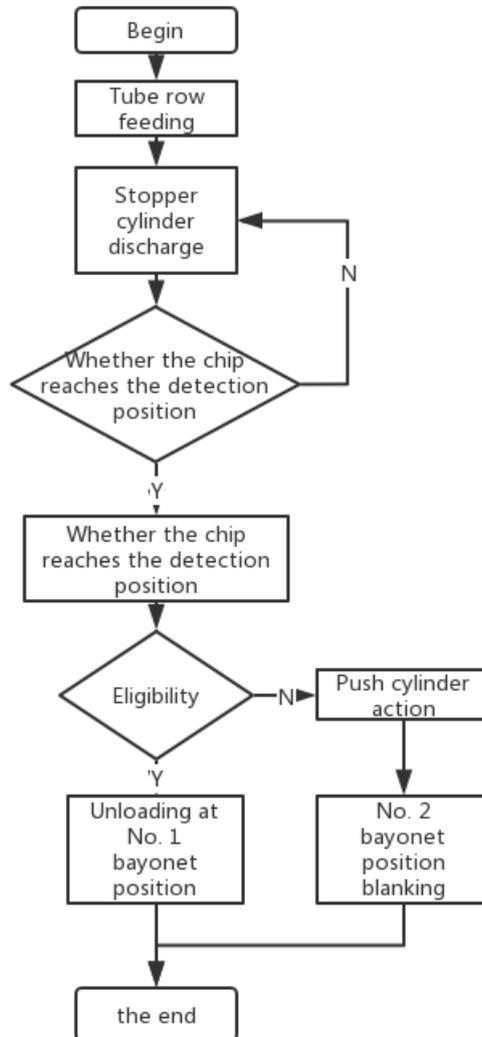


Fig. 7 Automatic detection process

### 5.2 PLC programming

The PLC program written with the idea of modular programming can effectively reduce the coupling between each action program, reduce the complexity of the program, and facilitate later functional improvement and maintenance. In actual engineering projects, a large amount of data exchange and transmission are required between the PC upper computer and the PLC. The PC needs to transmit user control signals to the PLC control system, and at the same time, the PLC needs to collect the operating data of the control system and transmit it to the PC for monitoring and display in real time. Therefore, it is necessary to establish communication between the two, which can greatly improve the performance of the system.

In this study, the above-mentioned serial communication method was selected to realize the communication method between PLC and PC. Here, PLC and PC have multiple communication protocols including serial port communication protocol, TCP/IP protocol, IPX/SPX protocol. The communication protocol adopted by the PLC control system this time is the serial communication protocol.

## 6. Conclusion

Whether it is the expansion of machine vision applications or the advancement of upstream and downstream fields, under the influence of multiple factors, the rise of machine vision technology is an inevitable scientific and technological means and method. With the maturity of industrial automation technology, more and more companies have begun to adopt machine vision in order to maximize benefits. Since the initial development is not complete, there is still huge room for development in these fields in the future. At the same time, with the evolution of the artificial intelligence era, machine vision will appear more in emerging fields, such as intelligent robots, autonomous driving, face recognition, tracking and positioning, security monitoring, medical imaging and other visual image applications. In addition, the machine vision technology award is gradually moving towards the public's field of vision, and this trend is closely related to its application field.

At present, machine vision is a little unfamiliar to various industries due to its professionalism and limitations in application fields. However, with the broadening of application fields, machine vision will appear in scenes closer to daily life, and it will be compared with other Cross-integration of industries makes it more inclusive and popular.

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