Construction of intelligent testing system for electronic components

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Abstract. In order to solve the problems such as unreasonable plan, opaque process, insufficient flexibility and excessive manual participation in the process of screening, identification and quality consistency inspection of electronic components in China, a software and hardware construction scheme of intelligent detection system for electronic components is proposed, which integrates the cutting-edge technologies such as machine vision, deep learning, IOT(internet of things), data mining. Relying on the National Semiconductor Device Quality Supervision and Inspection Center, part of the construction work has been completed, and the information, automation and intelligence of the testing business have been realized.

1. Introduction

As the core foundation of the top-level planning such as new infrastructure construction, Internet plus and, electronic components have the characteristics of many varieties, complex processes and high quality requirements, and their testing covers the whole cycle of evaluation, procurement, screening, use and failure analysis. The traditional inspection and control of components is not transparent, unreasonable planning, too much manual participation, low degree of automation, resulting in low efficiency, strong subjectivity and other outstanding problems, it is more and more difficult to meet the urgent needs of efficient, accurate and intelligent detection of components.

The mode of "intelligent detection" has not been put forward in the world, and there is only the cutting-edge idea of "intelligent manufacturing", which is typically represented by the enterprise research such as Cisco's Internet of things and the national strategy such as Germany's industrial 4.0[1, 2]. The exploration of intelligent detection is only aimed at a single technology. The virtual instrument measurement of American National Instruments and the wireless testing instruments of FLUKE represent the development trend of electronic measurement equipment informatization [3,4].

As the national team and vanguard of components inspection, the National Semiconductor Device Quality Supervision and Inspection Center has carried out the early exploration of informatization and developed a series of intelligent special equipment. It can be realized the omni-directional intelligent
management of testing business by build an intelligent testing innovation platform with information sharing, intelligent perception, scientific decision-making and multi-service integration.

2. Architecture of intelligent detection system for electronic components

At present, the intelligent detection of electronic components mainly has the following problems:

1) Traditional component testing equipment are independent equipment operated manually, such as body type microscope, X-ray microscope, centrifuge, vibration table, component tester, etc., which are subjectively judged to be qualified or not by batch inspection of manual operation test equipment. There are some prominent problems such as heavy repetitive workload and subjective qualification judgment [5].

2) The detection information management system of the testing organization is only the network electronic of paper process, and does not use sensor and Internet of things technology to realize real-time practical information collection.

3) At present, the internal transfer of samples in all testing institutions is manual single pass multi batch transfer, which has problems of poor anti-static effect, low transmission efficiency and high risk of mixed batch.

4) There is a large amount of reliability and detection management information hidden in the process of detection. The traditional database technology can only list them for query. However, these big data contain many reliability indicators, such as the reliability of components, environmental adaptability, quality consistency, which are difficult to obtain through a small amount of single batch data, and need to be mined urgently.

Based on the actual characteristics of inspection and detection of electronic components, intelligent requirements and hierarchical structure of software and hardware, the innovative intelligent detection platform mainly creates six modules: Command and dispatch subsystem, detection information management subsystem, IOT data interaction subsystem, intelligent test subsystem, intelligent storage subsystem and big data analysis subsystem, as Figure 1.

Command and dispatch subsystem: the subsystem extracts and analyzes the data in the detection information management subsystem, and combines the data mining information in the big data analysis subsystem to analyze and predict the detection business saturation, the use of key equipment, timeliness index, component reliability, etc., so as to provide decision support for senior managers.

Detection information management subsystem: track and control the process of all testing tasks, and use the IOT interactive subsystem to call the use status information of testing and storage equipment, so as to provide seamless connection for inspectors to control the inspection process of each batch of products.

IOT data interaction subsystem: as the perception element of the whole intelligent detection platform, it can collect the data of intelligent test equipment, environment data, test data and other data, and integrate the logistics information in the intelligent warehouse subsystem.

Intelligent test subsystem: it is mainly composed of machine vision function, motion control function and intelligent mechanical function. Aiming at the characteristics of various types of components to be inspected, small package and disorder in bulk, it focuses on solving the problems of visual identification technology, positive and negative discrimination technology, defect detection technology, intelligent grasping technology, precise transmission technology and automatic turnover technology, so as to realize the components automatically, defect discrimination, automatic counting, heterogeneous screening, size measurement, automatic nesting and other functions [6].

Intelligent warehouse subsystem: the robot technology is used to build the intelligent warehouse subsystem, which can realize the automatic sorting, automatic nesting and intelligent distribution of electronic components, and improve the internal logistics productivity.

Big data analysis subsystem: according to the massive data requirements of the other five subsystems and their respective data characteristics, the big data analysis technology suitable for different structural characteristics is used to fully mine the value information hidden in the testing process.
Fig. 1 System block diagram of intelligent detection platform for electronic components
3. Design and implementation of intelligent detection subsystem for components

3.1. Command and dispatch subsystem

A complete top-level architecture is the premise for the perfect operation of the system. According to the complex system and requirements of the testing industry, the intelligent detection platform architecture is divided into four levels: object interconnection layer, object perception layer, data analysis layer and business application layer, which realizes the "four modernizations" of detection interconnection, digitization, informatization and intellectualization.

According to the needs of decision-making level of testing institutions, command and dispatch subsystem mainly realizes the full extraction of detection tasks, resources and other information in the platform.

3.2. Detection information management subsystem

At present, the National Semiconductor Quality Supervision and Inspection Center has independently developed the inspection management system, which has achieved paperless in all stages and traceability of the whole process, which has reached the leading level in the industry. According to the characteristics of the whole process of more than 50 tests in component testing, it has continuously designed and improved the inspection information management subsystem with four functions of task management, logistics management, resource management and scheduling. The detection information management subsystem is further improved by iteration, as Figure 2.

![Fig. 2 Test information management system of National Semiconductor Quality Supervision and Inspection Center](image)

3.3. IOT data interaction subsystem

Whether the data information used by the detection information management subsystem is comprehensive or not depends on whether the complete information can be collected. IOT interaction technology can provide comprehensive full cycle information for the system. Through the research of 5G Internet of Things access technology, using the ultra-high computing power of cloud platform to complete real-time image processing and defect detection and other tasks with large amount of calculation, and realize the ultra-high speed transmission from terminal detection equipment to big data platform. At the same time, in order to realize the state perception and automatic control of all intelligent detection equipment, it is necessary to design a data architecture that can realize the automatic collection and transmission of operation data, and provide the "man-machine material method loop" in the detection process to the management system in real time to realize intelligent control.
3.4. Intelligent test subsystem

The intelligent test subsystem of high efficiency, standard, accuracy and system needs to focus on solving the deep learning machine vision and small sample processing to meet the requirements of automation, standardization, high efficiency, non-contact and no damage intelligent test and detection according to the factors limiting the efficiency and accuracy of traditional detection and the corresponding intelligent technology[7].

3.4.1. Intelligent detection technology of components based on machine vision

Visual recognition technology is introduced into the component detection, and the functions of defect detection and size measurement of components are realized by building optical imaging and image acquisition hardware module and image discrimination visual inspection software module, and cooperate with the mechanical transmission module to achieve automatic nesting and other functions.

At present, the mainstream visual inspection methods are divided into classical machine vision and deep learning machine vision. The classical machine vision has been more mature, but in the component inspection, there are many kinds of products, many kinds of defects, a lot of manpower in designing templates, and different lighting requirements for different devices. Deep neural network is the core technology of deep learning. It is less affected by illumination, good generalization and not limited to fixed template. It can be applied to different types of detection tasks. However, it faces the problems of small sample size, manual labeling and extra labor cost. In order to take into account the diversity of components and the accuracy and efficiency of detection, the method of combining deep learning algorithm with classical algorithm is proposed. The problem of small samples in deep learning is solved by generating model. Automatic labeling algorithm is designed based on semi-supervised model to improve the accuracy of neural network and achieve the optimal effect. Our company has developed a variety of machine vision inspection equipment. Figure 3 shows the counting and discrimination system of components.

![Component recognition system based on machine vision](image)

Fig. 3 Component recognition system based on machine vision

3.4.2. Intelligent grasping and transmission technology of micro components

This technology focuses on solving the problems of intelligent grasping, accurate transmission and automatic overturning.

It is the key step of intelligent experiments to grasp the disordered components with different sizes and packages. The optimal grasping scheme is determined by comparative experiments on SCARA and other mechanical arms, vacuum adsorption and other material grippers.
Micro components have high requirements for transmission accuracy. In this paper, the precise transmission is realized by optimizing motion control feedback, optimizing path planning and optimizing transmission speed.

At the same time, due to the small and thin components, the conventional clamping flipping and picking mechanism is not competent for the component flipping task. This unit uses the flipped cylinder to design a rotary adsorption manipulator to achieve this function. Figure 4 shows the automatic turning over and cleaning system for components developed by our unit.

![Fig.4 Automatic cleaning system for components](image)

3.5. Intelligent warehouse subsystem
This part mainly studies the multi-robot task description, task assignment and autonomous path planning strategy which accords with the characteristics of the detection mechanism. The task allocation algorithm is designed on the client side, and the path planning algorithm is designed on each robot to realize the free communication among the multi-robot lower computer platform, the client host computer platform and the automatic centralized scheduling platform.

3.6. Big data analysis subsystem
This part consists of the underlying bottom data warehouse and upper layer data mining.

In view of the high noise, diversity and multi-scale characteristics of the original data of the intelligent detection equipment and the full cycle data of the discrimination image data set, the HDFS and other distributed big data storage and processing technologies are studied, and the data cleaning and integration are carried out, and the theme oriented data warehouse for multi-dimensional business and high-dimensional characteristics of intelligent detection is constructed.

In view of massive detection data, TensorRT and Spark big data calculation are deeply studied, and high-order data mining algorithm is designed to realize the life cycle analysis and quality regression analysis of components [8]. Figure 5 shows the big data analysis subsystem developed by our company.

4. Effectiveness of intelligent detection system construction
The project has completed the development and construction of command and dispatch subsystem, detection information management subsystem, IOT data interaction subsystem, intelligent test subsystem, intelligent warehousing and big data analysis subsystem, which has increased the labor productivity of the unit by 15%, reduced the production cost by 10%, and saved the cost by 4 million yuan per year, and the following goals have been achieved:

1) The center management mode based on detection command and dispatch is realized, and intelligent decision is provided.

2) A complete detection management process network is constructed to realize seamless management and control of the information flow and logistics operation of the detection link.
3) It realizes the automation, interconnection and intellectualization of the detection equipment, greatly improves the detection efficiency, and realizes the automatic recording and network real-time monitoring of the detection data.

4) The flexibility of the detection process is realized, and the machine vision technology is used to meet the needs of different kinds of components detection, which greatly improves the utilization rate of equipment resources.

5) It has the means of data collection in the whole process, realizes the information management of warehousing, planning, production and quality, refines the feedback product reliability short board through big data analysis, and improves the quality and reliability of components.

Based on the in-depth research and innovative construction achievements of electronic components intelligent detection, it can be applied to the inspection and testing field of other products in the future, and realize the industry 4.0 of inspection and testing industry.

5. Conclusion

Through the construction of innovation base for intelligent inspection of electronic components in the National Semiconductor Quality Supervision and Inspection Center, the interdisciplinary technologies of component detection, machine vision, intelligent robot, big data analysis and other fields are deeply studied, which fills the gap of intelligent component detection in the field of domestic component inspection.

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