Application of Machine Vision Automation in Quality Inspection of Electronic Components

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Abstract: This paper expounds the importance of electronic components as the core components of modern electronic equipment and its strict requirements for production quality inspection. In view of the low efficiency and accuracy of traditional manual inspection methods, this paper introduces the research theme of machine vision automation technology to explore its potential and advantages in improving the quality inspection of electronic components. In terms of methods, this paper expounds the definition, development course, main technical characteristics and basic composition of machine vision technology in detail, including image acquisition equipment, image processing software, actuator and so on. At the same time, the working principle of machine vision technology is explained, and its application in appearance inspection, size measurement and defect identification of electronic components is introduced. Research shows that machine vision technology can significantly improve the efficiency and accuracy of electronic components production quality inspection, and overcome the limitations of traditional inspection methods. At the same time, this paper also analyzes the challenges that this technology may encounter in the process of popularization and application, such as technical cost, talent shortage, standardization and so on, and looks forward to its future development prospects.

1. Introduction

In modern electronic equipment, electronic components play a vital role [1]. They are the basic units of various electronic devices, and are responsible for the functions of signal transmission, processing, storage and control. With the rapid development of science and technology, electronic equipment requires higher and higher performance and quality of electronic components [2]. A tiny component failure may lead to the failure of the whole equipment, and even lead to serious safety accidents [3]. Therefore, the production quality of electronic components must be strictly controlled.

The traditional quality inspection of electronic components mainly depends on manual work. Although this method can ensure the quality of detection to a certain extent, it also has obvious limitations [4]. The efficiency of manual detection is relatively low, and it is difficult to meet the needs of mass production. At the same time, the accuracy of manual detection is greatly influenced by the subjective factors and experience level of the inspectors, which is prone to misjudgment and missed detection [5]. Repeated work for a long time may also lead to fatigue and decreased attention of inspectors, further affecting the quality of testing. In order to solve the limitations of traditional manual detection methods, machine vision automation technology came into being [6]. Machine vision is a technology that uses machines to measure and judge instead of human eyes. It can obtain the image information of objects through image acquisition equipment, and use image processing and analysis algorithms to process and identify the images, thus realizing automatic detection [7]. In industrial production, machine vision automation technology has been widely used, especially in the field of quality inspection. It can greatly improve the efficiency of detection, ensure the accuracy and stability of detection, and effectively avoid the errors caused by human factors.

It is of great significance to study the application of machine vision automation in the production quality inspection of electronic components. By introducing machine vision automation technology, we can realize efficient and accurate detection of electronic components, improve production

quality and efficiency, and reduce production costs and risks. This research can also provide useful reference for the application of machine vision technology in other fields, and promote the further development and application of machine vision technology.

2. Overview of machine vision automation technology

Essentially, machine vision technology endows the machine with the ability similar to human vision through cutting-edge image processing and analysis, and realizes the identification, quantification, positioning and evaluation of objects [8]. The origin of this technology can be traced back to the mid-20th century. With the continuous development of computer technology and image processing algorithms, machine vision technology has gradually shifted from theoretical research to industrial practice, and has become a vital part of automated production. The remarkable features of this technology include high accuracy, high efficiency, non-contact measurement, and excellent adaptability and expansibility.

The basic components of machine vision system are mainly divided into three parts: image acquisition unit, image processing program and execution unit. See Figure 1 for details:

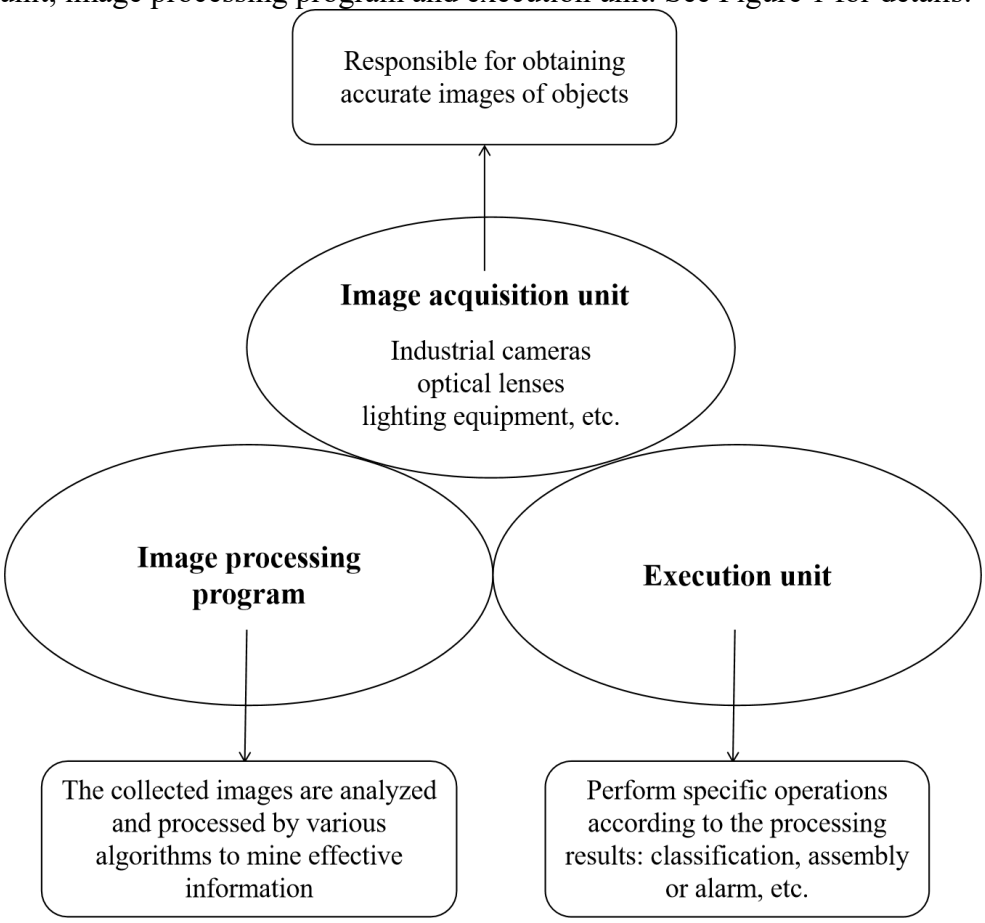

Figure 1 Basic components of machine vision system

The operation process of machine vision technology mainly includes key links such as image preprocessing, feature extraction, target recognition and classification. In the image preprocessing stage, the original image is denoised, enhanced and calibrated to improve the image quality. In the feature extraction stage, the shape, color, texture and other attributes of the object are separated from the optimized image. In the target recognition and classification stage, machine learning or deep learning algorithm is used to identify and classify features, so as to realize automatic detection of objects.

In the field of industrial automation, machine vision technology has been widely used by virtue of its unique advantages [9]. It can significantly improve the automation level of the production line, reduce manual intervention, and improve production efficiency and product quality. This

technology can also monitor the production process in real time and give early warning of faults, find and deal with problems in time, and reduce production risks and costs. In addition, machine vision technology has good adaptability and expansibility, and can be customized and optimized according to different production needs and environments to meet complex and diverse application scenarios. Machine vision technology has become one of the indispensable key technologies in modern industrial automation field.

3. The specific application of machine vision in the production quality inspection of electronic components

The heart of electronic equipment-electronic components, its quality inspection in the manufacturing process is particularly critical. In the production process of electronic components, several main inspection standards and requirements cover the completeness of appearance, the accuracy of size, and the internal or surface defects. These standards directly affect the performance and reliability of components, so their strict control is essential.

In the field of quality inspection of electronic components, machine vision technology plays an extremely important role. For appearance inspection, machine vision system can quickly acquire the images of components, and analyze these images through advanced image processing technology to accurately determine whether there are scratches, cracks or pollution on the surface of components. In the measurement of dimensions, machine vision technology uses its high-precision measurement algorithm to accurately measure the dimensions of components to ensure that they meet the predetermined design specifications. As for defect identification, machine vision system can intelligently identify the internal or surface defects of components with the help of cutting-edge technologies such as deep learning, and screen out unqualified products in time.

Table 1: Application Case of Machine Vision Inspection System in an Electronic Component Manufacturer

Seq. No.	Application Stage	Adopted Technology/Equipment	Specific Implementation Method	Realized Function	Experimental Result/Effect
1	Component Appearance and Dimension Inspection	Machine Vision Inspection System	Introduce the system and use high-speed industrial cameras to capture images of capacitors, resistors, and other components	Process and analyze the captured images	Accurately identify appearance defects and dimension deviations of components
1.1	Image Capture	High-speed Industrial Camera	Take clear images of components	Obtain original data on component appearance and dimensions	Images are clear, and data is accurate
1.2	Image Processing	Advanced Image Processing Algorithms	Preprocess the captured images, such as denoising and enhancement	Optimize image quality for analysis	Image quality is significantly improved, facilitating subsequent analysis
1.3	Image Analysis	Image Processing Algorithms	Perform feature extraction, comparison, and other analysis operations on the optimized images	Identify appearance defects and dimension deviations of components	Defects and deviations are accurately identified, improving inspection accuracy
2	Improvement of Production Quality Inspection Efficiency and Accuracy	Machine Vision Inspection System (Overall)	Apply the system to the production line, replacing or assisting manual inspection	Increase inspection speed and accuracy, reduce human errors	Significantly improve the efficiency and accuracy of production quality inspection

Table 1 lists in detail the specific application cases of electronic component manufacturers

introducing machine vision inspection system. The technology/equipment, specific implementation, realized functions and experimental results/effects are described in detail from the aspects of appearance and size detection of components. It can be clearly seen from the table that the machine vision inspection system plays a significant role in improving the efficiency and accuracy of production quality inspection.

With the introduction of machine vision technology, the efficiency and accuracy of production quality inspection of electronic components have been significantly improved. Compared with traditional manual inspection methods, machine vision technology shows its characteristics of rapidity, accuracy and stability. It can quickly detect components in batches, greatly accelerating the production process. Moreover, the machine vision technology reduces the possibility of human error and ensures the correctness of the detection results. The machine vision system can also realize all-weather uninterrupted operation, further improving the operation efficiency of the production line.

Compared with the old detection methods, machine vision technology shows its incomparable advantages. The traditional manual detection is not only inefficient, but also the detection results are generally not accurate enough due to the fatigue and distraction of operators. Machine vision technology effectively overcomes these problems and provides an efficient and accurate automatic detection scheme. For this reason, in the actual production activities, machine vision technology is gradually becoming the first choice for quality inspection of electronic components. It plays a key role in ensuring the quality and reliability of electronic components.

4. Machine vision automation technology development prospects and challenges

With the rapid development of science and technology, the application potential of machine vision automation technology in the field of electronic component quality inspection is expanding day by day. Looking forward to the future, this technology will be further closely integrated with the production process of electronic components, bringing more efficient and accurate testing experience. Thanks to the integration of advanced technologies such as deep learning and artificial intelligence, the performance and application scope of machine vision are expected to be greatly enhanced. The addition of deep learning will greatly enhance the self-learning and adaptability of machine vision system. Through the training of massive data, the system can identify various defects of electronic components more accurately, and can predict and evaluate potential unknown defects. The integration of artificial intelligence will make the machine vision system more intelligent, and can automatically adjust the inspection parameters and processes according to the production requirements, thus improving the inspection efficiency.

However, the promotion and application of machine vision automation technology also encountered some challenges. The cost problem is a difficult problem that has to be faced. High-quality image acquisition equipment, advanced image processing software and professional maintenance personnel all need large capital investment. In order to promote the wide application of machine vision automation technology in the production quality inspection of electronic components, the government and industry should increase investment in machine vision technology research and development to reduce costs and improve the technology popularization rate. The shortage of professionals is also an urgent problem. Machine vision technology requires interdisciplinary knowledge, such as optics, computer science, electronic engineering, etc., and such talents are relatively scarce. Therefore, we should pay attention to the cultivation and introduction of interdisciplinary talents and provide solid talent support for the development of technology. In addition, standardization is also a big problem faced by machine vision technology. Because the equipment and technical standards of different manufacturers are not uniform, this limits the compatibility and expansibility of machine vision system. Based on this, we should speed up the formulation of industry standards for machine vision technology, enhance the compatibility and expansibility of the system, and promote the standardization process of technology.

5. Conclusions

After the in-depth study of machine vision automation technology in the production quality inspection of electronic components, this paper finds the revolutionary changes brought by this technology. Machine vision technology greatly improves the accuracy and reliability of electronic components production quality inspection with its high precision, high efficiency and non-contact characteristics. It can quickly capture and analyze the subtle defects of components, and at the same time, it can maintain stable performance in complex and changeable production environment, which provides a strong guarantee for the quality and performance of electronic components. The application of this technology improves the automation level of the production line and greatly reduces the cost and risk of manual inspection. This has injected new vitality into the sustainable development of electronic component manufacturing industry.

The application of machine vision automation technology in the production quality inspection of electronic components has also promoted the innovation and progress of related technologies. In order to meet the increasingly high requirements for quality inspection in the production of electronic components, machine vision technology has been continuously integrated with cutting-edge technologies such as deep learning and artificial intelligence, and its performance and application scope have been continuously improved. The innovation and progress of this technology provide a broader space for the application of machine vision technology in electronic components industry, and at the same time provide useful reference for the application of other industries. In the future, with the continuous integration and innovation of deep learning, artificial intelligence and other technologies, the application prospect of machine vision automation technology in the production quality inspection of electronic components will be broader. We should give full play to the advantages of machine vision automation technology and contribute more to the high-quality development of electronic component manufacturing.

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