Development of automatic arrange system for disordered components in bulk

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Abstract. Due to the increasingly thin, chip, miniaturized and high-precision electronic components, the samples in many links of the production and testing process of components are scattered and disordered. Meanwhile, the low efficiency of manual testing and the instability of detection accuracy make the intelligent material discharging detection of components extremely urgent. In this paper, intelligent requirements for detection are comprehensively analyzed, and technologies such as machine vision imaging optimization, deep learning feature matching, and tiny sample grasping and placement are deeply studied. An automatic discharging system integrating counting module, defect detection module and automatic discharging module is developed to realize intelligent discharging detection of tiny bulk disordered devices.

1. Introduction
The production and testing of electronic components need to go through many links. In each link, the state of samples is scattered and disordered. At present, these disordered components in bulk should be arranged neatly in specific containers, as well as the mounting before acoustic scanning, X-ray, some electrical tests and other tests, as well as the counting and appearance inspection at the handover, etc. should be carried out manually.

Due to the small size and light weight of electronic components, they are becoming more and more thin, chip, miniaturized, high-precision and other characteristics, and the difficulty of electronic components detection is gradually increasing. However, the manual detection effect of tiny electronic components is easily affected by the fatigue degree of the tester, the amount of experience of the tester, the quality of the field environment and other factors, and has disadvantages such as low detection efficiency and unstable detection and identification accuracy. In addition, the number of electronic components production is extremely large, if only rely on manual detection, not only consume huge human cost, but also cannot guarantee the accuracy and speed of detection.

Machine vision detection is a detection technology based on computer vision and image processing technology. It get images of the objects, and take it as the detection target, through a series of image processing software to simulate the human visual function, and extract useful information or features [1]. Compared with human eyes, machine vision has the advantages of high efficiency, high speed, high precision, high stability, unlimited working time, information integration and low cost [2, 3].
With the gradual maturity of vision theory, the cost of execution is also decreasing year by year. Therefore, machine vision method is adopted in this paper to arrange and detect the products.

Table.1 Comparison between machine vision and manual layout inspection

| Test category   | Manual discharge detection | Machine vision discharge detection |
|-----------------|-----------------------------|-----------------------------------|
| Efficiency      | Low                         | High                              |
| Speed           | Slow                        | Fast                              |
| Accuracy        | Ordinary                    | High                              |
| Reliability     | Instable                    | Stable                            |
| Working hours   | Limited                     | Can be continuous for 24 hours    |
| Information integration | Unrealizable             | Realizable                        |
| Cost            | High                        | Low                               |
| Environment     | Not suitable for hazard detection environment | Suitable for hazard detection environment |

2. Automatic layout detection requirements for disordered components in bulk

The traditional method of material discharging and product detection is manual method. However, due to the shortcomings of this method and the substantial increase of human cost, the traditional manual material layout detection cannot meet the needs of modern large-scale production. Therefore, it is necessary to study new methods to replace the traditional manual material discharging detection method.

In view of the incomparable advantages of discharging detection in machine vision, and with the progress of machine vision technology and the popularization and improvement of related visual hardware, the application of machine vision technology for automatic discharging detection has become the general trend [4]. However, in the field of component detection at present, there is no equipment for automatic discharging detection for disordered components in bulk in the market [5], so the development of automatic discharging detection system is extremely urgent. This paper starts from urgently needed parts and components layout link in the electronic industry, and develops the automatic discharging system as the pilot of intelligent testing. The requirements for automatic layout of small and disordered components in bulk are refined, including automatic counting, automatic identification of defects and automatic discharging, etc., as shown in Figure 1.

![Fig.1 Requirements for automatic discharging of disordered components in bulk](image-url)
There are many types of electronic components with different appearance characteristics and various surface features and defects. At present, the common image-based recognition method in the market is difficult to solve the recognition and discrimination problems:

1) In the same acquisition environment, the results of different defect types are not the same. Sometimes, the acquisition conditions with good effect for a certain defect type cannot be suitable for other defect types;

2) The surface defects are extracted with high precision, and the general size is mm. The precision level directly affects the design of the detection system;

3) The surface of components is generally engraved with characters, which increases the difficulty of acquisition and defect extraction, and the existence of characters also produces glossy defects.

All of the above problems will cause difficulties in sensor imaging and machine vision processing, so it is necessary to carry out further targeted technical research and design.

3. Design of automatic material layout system for disordered components in bulk

3.1. Overall architecture design

Based on the requirements of material discharging and mounting before the acoustic scanning, X-ray and some electrical tests, as well as the requirements of sample counting and appearance inspection involved during the sample handover before and after the test, the automatic discharging system for bulk disordered components is further divided into component counting module, visual inspection module and automatic discharging module from the overall architecture.

The component counting module realizes the counting function of sample handover and storage. The appearance inspection module realizes the function of sample appearance inspection before and after the test, and can also carry out the photographic archive of components, authenticity discrimination, heterogeneous screening and external visual inspection test of components. Based on the results of machine vision detection, the automatic discharging module realizes the functions of sample mounting before acoustic scanning, X-ray, electron microscope and sample preparation before electrical test. The three modules are closely linked and indispensable.

3.2. Development of counting module

The component counting module is composed of image shooting mechanism and computing system, which includes industrial camera, light source and auxiliary mold, etc [6]. There are two kinds of image acquisition schemes: high-definition camera with telecentric lens, or linear array camera scanning scheme.

Due to the small size part components, such as 0402 package size is only 1 mm * 0.5 mm, according to the effective observation range for 150 mm * 200 mm, if use high-definition camera, in order to ensure that each device has more than 100 pixels, need at least more than 6 million pixels. Considering the edge of the low utilization ratio, 8-10 million pixel high-definition camera should be needed. Considering the high thickness of some components, only the telecentric camera can effectively reduce the projection effect. The disadvantage of this scheme is that it is easy to be affected by sample projection.

The working mode of line-array camera is similar to that of a mobile phone shooting panoramic photo. A mechanical structure drives line-array camera to scan the entire observation range, so that high-definition and no shadow images can be well obtained for further processing. The disadvantages of this scheme are high cost and the need for machinery.

The linear array camera is used in this system because of the high precision requirement of components and the high labor cost.

The counting algorithm based on machine vision is adopted to complete the software, and the counting process is shown in Figure 2.
3.3. Development of surface defect detection module

The hardware part of the defect detection module of bulk disordered components includes lighting, lens, camera, image acquisition card, visual processor, and some auxiliary modules.

The appearance inspection first completes the image acquisition, and the electronic components are automatically photographed by the image acquisition equipment according to the set acquisition frequency, and the shooting results are transmitted to the computer processing system. Since the appearance inspection of components requires a certain magnification, it is necessary to design an electronic microscope with electronic eyepiece which can automatically find the target and focus automatically as the lens of appearance inspection module. The hardware includes continuous zoom electronic objective microscope, electric focusing device and electric zoom device. The software includes auto-focus algorithm, auto-focus algorithm and traversal algorithm [7, 8].

Based on electronic defect characteristics, this paper compares the Caffe, Keras, PyTorch three kinds of commonly used deep learning framework the advantages and disadvantages, choose image to create, load, debugging more convenient PyTorch deep learning framework, and adopt DeepLab semantic segmentation algorithm to realize the automatic identification of the components defects through the training of defect free target and defective target sets.

3.4. Development of automatic discharging module

Scattered disorderly components are faced with the problems of front and back devices mixing, side standing, stacking and so on. To carry out automatic discharging of them, it is necessary to solve the technology of automatic positioning, automatic turning over, automatic transfer, automatic positioning and placement, etc., so as to realize the functions of mounting and all kinds of tests before sound scanning and X-ray testing, automatic discharging and packing after testing.

The development of automatic discharging module is mainly based on machine vision system and complex mechanical platform, which can automatically complete the pre-arranged placement of components in bulk; it can automatically locate all materials through machine vision and select its geometric center, which is easy to grasp later. Be able to determine the positive and negative of materials; it can automatically reverse the bottom facing materials to ensure that the final direction of components is consistent. It can guide the manipulator arm to grasp materials and place them in the designated position through machine vision.
There are many sample types and package types involved in component testing, such as SOT (small profile transistor), DIP (dual in-line package), QFP (square flat package), etc., but different encapsulation device identification and the automatic detection method of each are not identical, so for common packaging carried out personalized automatic identification technology and the automatic fetching technology research, including automatic identification of component, positive and negative, direction of the method, as well as components automatic positioning, absorption, clamping, rotation and turning of components and parts, etc.

The hardware part of the automatic nesting module is mainly composed of mechanical structure and electronic control system. The motion control card and upper computer are used to realize the motion control, and the machine vision technology is used to realize the pose and position parameters recognition of components, which can meet the working requirements of different components. The device is equipped with an automatic turning mechanism, which can automatically identify the front and back sides of the components and perform the overturning of the components to ensure the consistency of the front and back sides of the device.

Compared with the common mechanical structures such as XYZ, SCARA, series and parallel, the XYZ manipulator with classic, stable structure, large load-bearing and mature control mode is selected. And combined with the characteristics of small components, the automatic discharging module is designed and realized by using pneumatic suction nozzle, mechanical claw, flexible manipulator and other grasping devices.

4. Effectiveness of intelligent detection system construction
The automatic arrange system for disordered components in bulk has been built, as shown in Figure 3. After testing, the system has achieved the following performance:

1) Realize the identification, layout and counting of at least 8 kinds of packages.
2) Discharging speed: < 10s / piece.
3) Discharging accuracy: 1 mm.
4) Maximum identification quantity of single batch: 500 pieces.
5) Counting speed: < 20s / batch.
6) Counting accuracy: was 99.99%.

Fig.3 Automatic detection system for disordered components in bulk

5. Conclusion
Through the development of the automatic arrange system for bulk disordered components, this paper introduces deep learning machine vision technology into the component inspection field for the first time, which greatly improves the detection efficiency, reduces the labor cost, and produces good economic benefits.

It also finds the great development space and potential of machine vision technology in the field of electronic components reliability, which can promote electronic components, is of great significance to develop the inspection technology and improve the level of automatic detection.
References
[1] Wang W C, Chen S L, Chen L B. A Machine Vision Based Automatic Optical Inspection System for Measuring Drilling Quality of Printed Circuit Boards[J]. IEEE Access, 2017, 5: 10817-10833.
[2] Ardhy F, Hariadi F I. Development of SBC based machine-vision system for PCB board assembly Automatic Optical Inspection[C]. International Symposium on Electronics and Smart Devices, 2017: 386-393.
[3] Raghuvanshi V, Burman A, Bartakke P P, et al. PCB solder pad inspection mechanism using gerber file[C]. International Conference on Communication and Signal Processing, 2016: 1321-1325.
[4] Chen Z, Zhou D, Liao H, et al. Precision Alignment of Optical Fibers Based on Telecentric Stereo Microvision[J]. IEEE/ASME Transactions on Mechatronics, 2016, 21(4): 1924-1934.
[5] Kuang Y, Li J, Liang J, et al. Research on Extracting Feature Points of Electronic-Component Pins[C]. International Conference on Intelligent Robotics and Applications, 2017: 611-622.
[6] Dr. Peter Mario Schwider. Following the CMOS Track: CMOS image sensors replacing CCDs in most applications[J]. Optik & Photonik, 2016, 11(4): 40-43.
[7] Silver D, Huang A, Maddison C J, et al. Mastering the game of Go with deep neural networks and tree search[J]. Nature, 2016, 529(7587): 484-489.
[8] Belazzougui D, Raffinot M. Approximate regular expression matching with multi-strings[J]. Journal of Discrete Algorithms, 2013, 18:14-21.