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Automatic Visual Inspection System for Tape Carrier Package Using Unique Image Processing and Human Visual Support

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Abstract

An automatic visual inspection system for the Tape Carrier Package (TCP) has been developed. To achieve low cost implementation and high speed inspection, we integrated unique image processing (0.7sec/device) to screen TCP devices which appear to be defective, with multiple illuminations to enhance defect images and a human interface for operators to finally judge the quality of the TCP. The operator can easily take part in judgments of the TCP quality. This system has been put into practical use in the final test process on TCP assembly lines.

1 Introduction

The Tape Carrier Package (TCP) is one of the new packaging techniques for electronic devices. With the TCP device, a silicone chip is molded by resist and carried on a tape. Up to now, the operator checked the TCP quality (cracks, stains, bent leads, etc.) in the final test process by visual inspection.

As the visual inspection is hard work for human eyes, and as human judgments of TCP quality are unreliable, an automatic visual inspection system for TCP is highly desirable. To begin with, we carefully observed and analyzed the actions of the operator. Based on this analysis, we came up with on new concept for an automatic visual inspection system for the TCP, and developed a unique algorithm of image processing and a human interface for operators to review. This paper presents the new concept and the practical system with the unique algorithm of image processing, and the human interface.

2 New Concept for This System

More than twenty types of defects are classified and registered in the TCP inspection standard for operators to detect. The operator's actions and judgments are very flexible depending on the types of defects. For example, using their common sense, experience, or advice from staff, operators can judge an unknown defect which is not exactly defined in the inspection standard. Their inspection threshold is varied for the quality of the lot. These flexible actions and judgments are very difficult to automate. A conventional automatic visual inspection system has been involved in the difficulties. As a result, even though a high performance sensor or artificial intelligence[1][2] is incorporated, it cannot be put into practical use for reasons of overkill, overlook, high cost implementation, low speed inspection, and so on.

First of all, we analyzed the actions of the operators (Figure 1) for the development of an automatic visual inspection system which can be put into practical use. Since it is necessary to judge the quality of many TCP devices in a short time, the operators move the tape at high speed using a tape handler and scan the TCP image on the monitor. When they notice something which happens to the image while moving the tape at high speed, they stop the tape and analyze the device to judge the quality. For example, they use a microscope, sweep the dust particle with tweezers, and compare the device with neighboring devices. Based on their analysis, they

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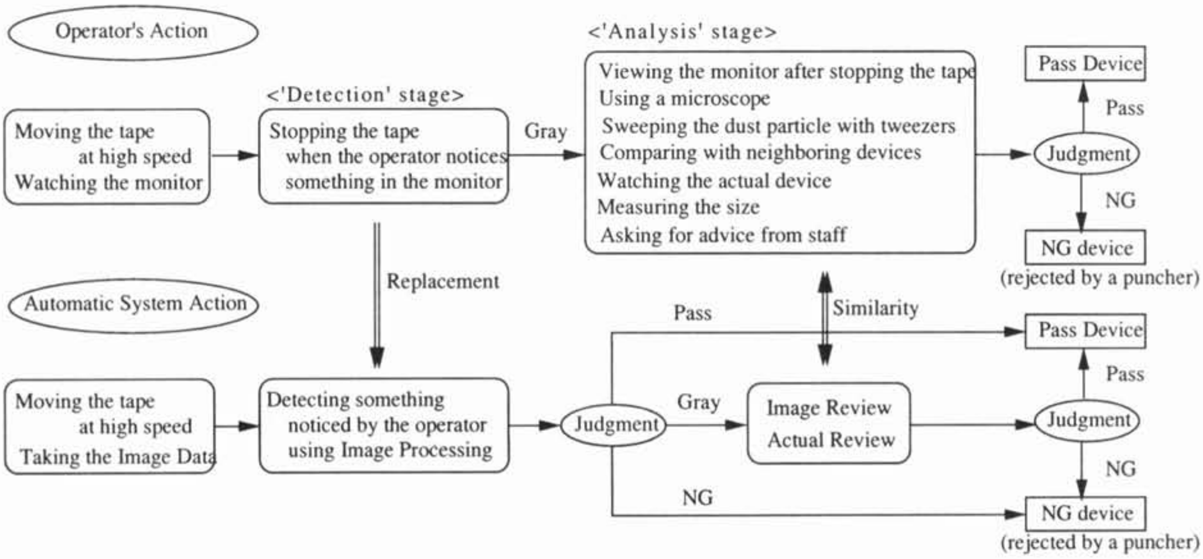

Figure 1: Concept of Automatic Visual Inspection System

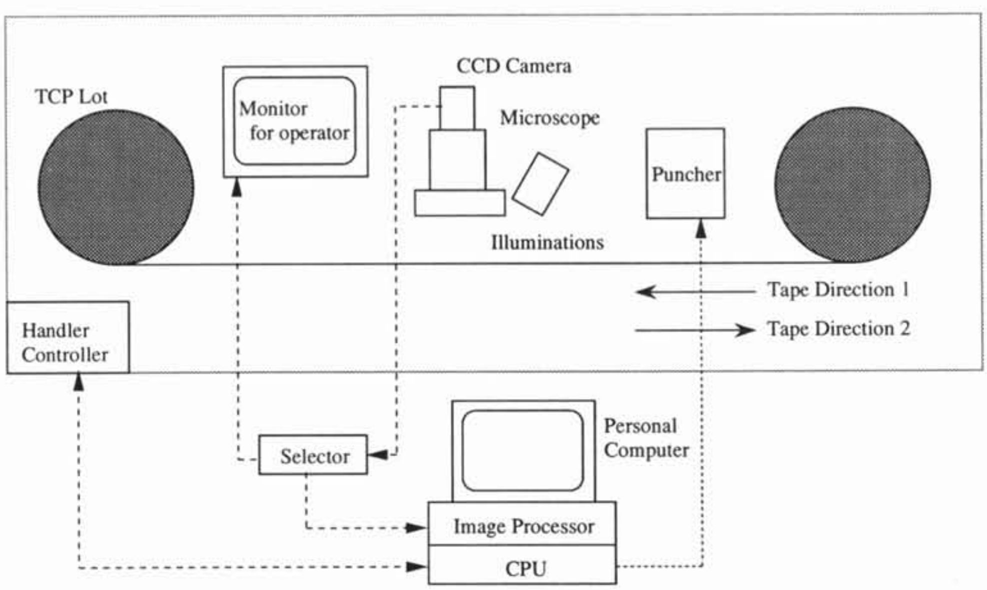

Figure 2: Configuration of Automatic Visual Inspection

Table 1: Process of Automatic Visual Inspection System

Stage	Process	<Device's Quality>
<'Detection' stage> (1) Automatic Inspection	Tape Direction 1. Screening by image processing.	All Gray Pass / Gray / NG
<'Analysis' stage> (2) Image Review	Tape Stopped. About Gray in (2), the operator judges using images stored in CPU.	Pass / Gray / NG
(3) Actual Review	Tape Direction 2. About Gray in (2), the operator judges based on 'Analysis' using actual devices. NG is finally rejected by a puncher.	Pass / NG

judge the quality of the TCP device. If it is 'NG' (no good), the device is rejected by a puncher.

By analyzing the operator's behavior, we found that the actions comprise of two stages. The first stage is 'Detection', and the second is 'Analysis'. At the 'Detection' stage, the operator notices something which happens to the image on the monitor while moving the tape at high speed. At the 'Analysis' stage, the operator judges the quality of TCP devices screened at the 'Detection' stage. As the operator seems to use simple information on the monitor at the 'Detection' stage, this stage can be automated by using image processing. The 'Analysis' stage is, however, difficult to automate using image processing alone. In place of automating the 'Analysis' stage, a human interface process for supporting this stage was introduced. Since the yield of TCP products today is so much improved that defective devices are rare, the operator's 'Analysis' process is tedious. Therefore the new concept is such that the total system is integrated with automatic 'Detection' stage and the human interface for supporting the 'Analysis' stage.

3 System Configuration and Process

Figure 2 shows the system configuration. Tabel 1 shows the process of the system.

4 Image Processing

The 'Detection' stage has been automated using an image processing technique. As operators notice something which happens to the image on the monitor while moving the tape at high speed in the 'Detection' stage, they can use only simple information on the monitor, for example, a change in brightness of the image, but they cannot detect a fine shape of the devices. A simple image algorithm processing, therefore, is applied to detect something which happens to the image on the monitor while moving the tape at high speed.

Figure 3 shows the algorithm. In order to enhance the contrast of defects, time-sharing multi-illuminations have been introduced; vertical and oblique illuminations for reflective images, vertical illuminations for transmitted images. The Sobel differential operator is applied to the multiple images obtained by the multi-illuminations.

Tabel 2 shows the performance of the image processing in this system.

The inspection speed is very high due to the following improvements.

- The algorithm of the image processing is very simple.
- The image processing is executed on the multiple image processors in parallel.
- The image processing is executed while moving the tape.

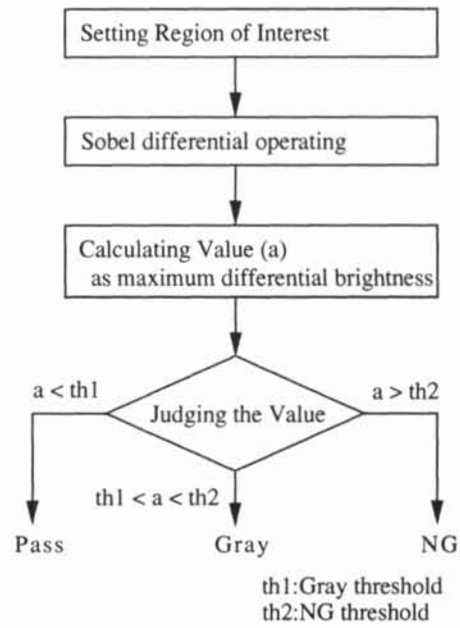

Figure 3: Algorithm of Image Processing

Table 2: Performance of Automatic Visual Inspection System

Inspection item	19 types
Inspection speed	less than 1.6 sec/device
(Image Processing Speed)	less than 0.7 sec/device
Screening number	5~10%
Overkill	less than p.p.m.
Overlook	less than p.p.m.

5 Human Interface

A human interface for supporting 'Analysis' has been introduced. It has two different types of methods, using images and actual devices (Table 1). In the image review, the operator judges the devices whose judgments at the 'Detection' are 'Gray'. Then they use the image data stored in the memory on 'Detection'. After the image review, the operator checks the devices which still remain 'Gray' by looking at their actual appearance. The operator corrects the screening judgment of the TCP device on both image and actual review. The defective device to be rejected by the puncher is rare because of high TCP quality (generally speaking, the yield is more than 99%). The threshold adjusts the number of screened devices by about 5~ 10% of the total number of a lot. Therefore, the operators need not spend much time for the review. While one system does screening as the automatic 'Detection', the operator carries out the review in another system. The Productivity has been doubled by introducing the automatic system.

6 Conclusion

The automatic visual inspection system for TCP has been successfully developed and put into practical use. The number of devices detected by screening is less than 5%. Since the operator can judge as few as 5% of the devices of the lot by the review system, overkill and overlook have been much reduced. The concept presented in this paper will be applied to automatizations of the same type of visual inspections.

References

[1] E.Mizutani, "Machine Vision Technology for Visual Inspection," Techno-System, pp.403, 1995.

[2] Y.Nakagawa, "Machine Vision Technology for Visual Inspection," Techno-System, pp.415, 1995.