Developing Image Processing Modules for the Automated BGA Inspection

Wen-Yen Wu and Chih-Chung Chen
Department of Industrial Management, I-Shou University
Kaohsiung Taiwan
wywu@isu.edu.tw

Abstract
Ball grid array (BGA) inspection is an important task. The objective of the paper is to develop an automated defect detection system that can increase the accuracy and efficiency of the BGA inspection process. In system implementation, the image of BGA solder balls is grabbed by a CCD (charge coupled device) in the ring light illuminating environment. Through some image-preprocessing techniques such as median filtering and thresholding, we can obtain a clear image. Followed by edge detection and the least square error circle fitting method, the center location and the diameter of each ball can be found. Consequently, pitch, offset, and roundness of each ball can be derived. In this paper, we focus on the development of image processing modules for the automated inspection of BGA. The concept of object oriented programming is used to construct the important components for an automated inspection system. Through a user-friendly interface, the user can easily establish their inspection flow. From the experimental results, the proposed method can process the BGA images effectively.

Keyword: ball grid array, automated inspection, object-orientated programming, image processing modules.

Introduction
As ball grid arrays and chip scale packages (CSP) devices are deployed in the industry, issues related to overall yield and reliability are becoming apparent. The key to successful manufacturing with ball grid array (BGA) devices is to provide inspection at the steps introducing special variations to common manufacturing problems. Screen-printing of solder ball is the first BGA assembly process that is most vulnerable to variations. Conventional visual inspection method using bear eye after screen-printing process was slow and inaccurate. The aim of the paper is to develop an automated BGA defect detection system that can recognizes ball defects such as missing-ball, double-ball, ball offset, undersized-ball, oversized ball. Therefore, the accuracy and efficiency of the BGA inspection process can be improved.

The primary goal for a manufacturing eye is to build systems that can globally understanding of a scene. The use of machine vision can have much contribution in this requirement. Niemann et al. (1990) indicated that three important applications of computer vision in industrial environments are (1) identification and location determination, (2) visual inspection, and (3) control of machines and processes. For the visual inspection tasks, one of the gaps between theoretical research and application is that it is difficult to establish a quick inspection method using the existing image processing modules.

Haralick (1986) indicated that the reason that deter the progress of machine vision is the lack of exact evaluation of system performances. The similar issue was also proposed by Pavlids (1992). Haralick (1992) proposed a performance evaluation schema by the thinning cases. Chan and Palmer (1995) and Malamasetal. (2002) surveyed literatures about machine vision applications for visual inspection, and proposed the suggested directions. Sablatnig (2000) proposed a general analysis graph to increasing the flexibility for automated visual inspection.
The other direction of applying image processing techniques to the inspection tasks is to develop an user-friendly interface to reduce the complexity of the inspection. Thomas and Calder (2001) devoted their researches to the development of graphical user interface (GUI). Besides, due to the restricted presentation of static GUI, they indicated that the animation may be helpful for users. Fraternali and Paolini (2000) proposed a method based on the modulation and internet technique to develop an Autoweb system. By setting some parameters, the user can easily establish their web. Liu and Lee (2002) used the established IC components for the testing tasks. The concept of modulation is the foundation of their work. Uhrmacher (2001) pointed that in developing a system, it is important to have the ability of error-prevention.

In this paper, we propose a method to establish the image processing modules in the inspection of ball grid arrays (BGA). A user-friendly GUI is developed to help users in the selections of operations in the BGA inspection. Besides, the inspection results can be collected and the control charts can be accessed via internet in real time (Montgomery, 2001).

**Image Processing Modules And Results**

For a BGA inspection system, five main processing stages are: image grabbing, image preprocessing, feature extraction, defect detection, and the result representation. Figure 1 shows the BGA inspection schema.

There are a lot of methodology have been applied in the inspection of ball grid array (BGA). Lin and Lue (2001) indicated the development of automated measurement machine to deal with (BGA) type printed circuit boards (PCB). They proposed to automate the boundary scan and circularity estimation by introducing the idea of the least-square circle to find the center of the holes and pads. The vision system, then, can easily inspect the local deviation when positioning table locates the PCB on the image capturing point. Chen (2001) introduced new rules for defect detection by comparing results of different methods of image processing. He found out threshold value for image segmentation and a better sub-pixel edge detect operator that can upgrade the inspection. To improve inspection efficiency, least square error cycle to approximate the shape of solder balls is applied. He, then, provided an improvement proposal for the compensation method of the moving angle deviation between BGA substrate and the charge-coupled device (CCD) camera during the image capture procedure.

![Figure 1. Outline of the BGA inspection schema.](image-url)
Table 1. Image processing modules.

<table>
<thead>
<tr>
<th>Icon</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Icon" /></td>
<td>Convert color image to gray image</td>
</tr>
<tr>
<td><img src="image2.png" alt="Icon" /></td>
<td>Median filter</td>
</tr>
<tr>
<td><img src="image3.png" alt="Icon" /></td>
<td>Smoothing</td>
</tr>
<tr>
<td><img src="image4.png" alt="Icon" /></td>
<td>Binarization operation</td>
</tr>
<tr>
<td><img src="image5.png" alt="Icon" /></td>
<td>Opening</td>
</tr>
<tr>
<td><img src="image6.png" alt="Icon" /></td>
<td>Laplacian filter</td>
</tr>
<tr>
<td><img src="image7.png" alt="Icon" /></td>
<td>Projection</td>
</tr>
<tr>
<td><img src="image8.png" alt="Icon" /></td>
<td>Find the centre of object</td>
</tr>
<tr>
<td><img src="image9.png" alt="Icon" /></td>
<td>Area computation</td>
</tr>
<tr>
<td><img src="image10.png" alt="Icon" /></td>
<td>Deformation ratio</td>
</tr>
<tr>
<td><img src="image11.png" alt="Icon" /></td>
<td>Centre finding by regression</td>
</tr>
</tbody>
</table>

In consideration of captured image may contain much nuisance factors, which can disturb the processing and may lead to misjudge the results, suppress noise is essential to decrease these interferences. Medianpass filter is one of the effective tools and frequently been used for this purpose, since the distortion on image it brings is quite low. To establish the image processing modules, users can select their desired modules and apply the selected modules to their inspection tasks. In this paper, we construct some common modules and it is listed in Table 1.

Figure 2 shows the graphical user interface that user can choose the desired operations by dropping the corresponding icons to the proper position. Since some of the processing operations are precedence and they should be performed step by step.
Figure 2. Image processing interface.

Figure 3 shows the error-prevention when an incorrect flow occurs. After correctly setting processing flow as shown in Figure 4, the BGA image can be processing and inspected. Binary threshold, then, is hold to distinguish solder ball from board image. It is an extreme approach to obviously obtain solder ball image for further feature extraction. Next, each solder ball in image is labeling, the same object is tagged with similar chromosome number. That is, each pixel in one solder ball will be assigned to the same number.

Figure 3. Error-prevention in selecting operations.

Figure 4. The selected operations shown in icons.

The inspection result is demonstrated in Figure 5. Further, the information of defects can be accessed from the internet and the control charts are constructed in the same time.
Figure 5. The processing result of the BGA image.

Figure 6 is an example of the control charts listed in browser. The manager can easily monitor the manufacturing processes via internet.

Figure 6. Output of control chart.

Discussions

In this paper, we propose a method for establishing image processing modules. A user-friendly interface was implemented to increase the applicability for BGA inspection tasks. The inspection results are also presented in the form of statistical control charts. Besides, the control charts can be accessed via internet in real time. From the implementation of the proposed method, it is seen that the inspection task of BGA can be easily performed and it is hopefully applied to the other inspection cases.

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References

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