Application of image processing in the detection of printed circuit board

Xiaojing Tian
School of Mechanical Engineering
Dalian Jiaotong University
Dalian 116028,China
tzy@djtu.edu.cn

Liang Zhao
School of Mechanical Engineering
Dalian Jiaotong University
Dalian 116028,China

Huajun Dong
School of Mechanical Engineering
Dalian Jiaotong University
Dalian 116028,China

Abstract—**It is inevitable that there will appear defections such as the appearance's not neat, solder mask's unevenness, lines' and pads' damages in the production of printed circuit board. In this paper an image acquisition system of the circuit board is designed. Digital image processing technology has been carried on the analysis of the collected image. In image preprocessing,these processing methods as image enhancement, edge detection, the two value processing method have been used to improve the image quality. In the extraction and recognition of the defection , subtraction method is used to perform the detection of the defect board through the comparison and matching of the defect image and the template image.**

Keywords- circuit board images, image enhancement, edge detection, binarization, subtraction method

I. INTRODUCTION

The quality of modern electronic equipment relies not only on the electronic components' quality and performance, and depends on the quality of printed circuit board to a great extent. It is inevitable that there will appear defections such as the appearance's not neat, solder mask's unevenness, lines' and pads' damages in the production of printed circuit board[1]. Online detection is a necessary segment to ensure the quality of circuit board. In paper the detection system to the final board is introduced，which is significant to guarantee the production quality [2].

Electrical and optical detections are the two kinds of quality inspections of printed circuit board. And visual detection technology based on image processing has been becoming one of the hot researching aspects with the advantages of non-contact, fast speed, appropriate precision, strong ability of anti interference[3,4]. The image visual inspection system for printed circuit board can recognize those defections as bad welding point, even for solder, copper and platinum breaking point, short circuit etc. through the digital image processing and recognition technology.

Image processing has two purposes, one is to generate images more suitable for human observation and identification, the other is to recognize and understand images automa-tically.The system includes image acquisition system, image enhancement，edge detection，defect detection. We try to use subtraction method to perform defect detection of printed circuit boards. The system is aimed to facilitate the actual operations which can provide a basis for the online,fast and accurate detection of printed circuit boards.

II. IMAGE ACQUISITION SYSTEM

Fig.1 shows the acquisition system of the printed circuit board. The system is composed of feeding machine, light sources, conveyor belt, a CCD camera and the controlling board. Conveyor belt is used to automatically transmit detected circuit boards. According to the requirements, we fix the CCD camera on the position which is vertical to the detected boards. The speed of the belt should match the CCD acquisition rate. The whole processing procedure consists of three steps. Firstly, the detected boards should be placed in the illuminated backgrounds as far as possible, and through regulating optical lens, setting the CCD camera resolution and exposure time, the circuit board images collected by CCD are saved to PC. Then the image preprocessing and feature extraction is followed. Finally output the results and sort the qualified and unqualified boards.
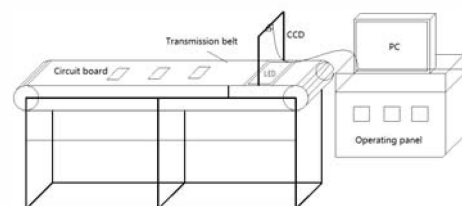

Figure 1. Acquisition system

III. IMAGE ENHANCEMENT

Image gray transformation and image smoothing are the two methods of image enhancement. Gray level correction is a simple and effective way to enhance image in spatial domain. It mainly includes the image histogram equalization, increasing contrast and histogram modification. Different image correction method is selected according to different requirements[5]. Based on the gray transformation theory, combined with image scale transform method, two-

dimensional image gray equalization is achieved in this paper. The transformation formula[6] is as below.

$$g(x,y) = \begin{cases} (c/a)f(x,y) & 0 \le f(x,y) \le a \\ [(d-c)/(b-a)]f(x,y) + C & a \le f(x,y) \le b \\ [(M_s - d)/(M_f - b)][f(x,y) - b] + d & b \le f(x,y) \le M_f \end{cases}$$

In which:

M_s —Minimum gray

M_f —Maximum gray

f(x, y)—Original image matrix

g(x, y)—Transformed image matrix

Fig.2 is the gray enhancement image of a printed circuit board. And a) is the original image diagram, b) is the diagram of the processed gray enhancement image. The gray transform processing can increase the dynamic range, expand the image contrast, and make the image clearer.
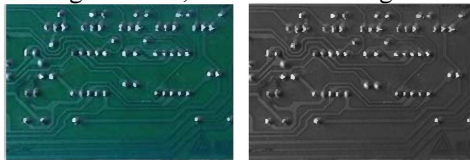
a) Original Image   b）Enhancement Image
Figure 2. Gray Enhancement Image

IV. EDGE DETECTION

The edge of the object is reflected by the discontinuity of gray level. It can be divided into step edges and roof edges according to the characteristics[7]. And the purpose of edge detection is to obtain external contour features of the image. In this paper, the experiments of edge detection are processed by different classic operators to the collected circuit board. Fig. 3 shows the edge detected images. We can see that Roberts, Sobel and Prewitt operators have better effects on edge detection of the spot, while Log and Canny operators play a better detection effect on the connection of circuit board. So we can choose different edge detection operators for different detecting targets.
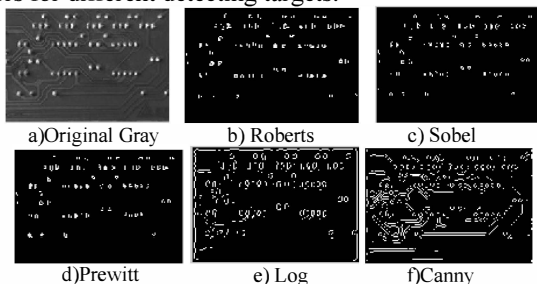
a)Original Gray   b) Roberts   c) Sobel

d)Prewitt   e) Log   f)Canny
Figure 3. Edge Detection of Different Operators

V. IMAGE BINARIZATION

As the edges extracted by traditional edge detection operators usually have the defects of false edge, non-connecting, sensitivity of noises, aperture effect. Edge detection is just the basis of image binarization. Binarization image has only black and white colors in the image.It is the process of pixel classification in essence and it's an important technology to get the image contour [8]. Mathematical morphological opening operation can be used to eliminate small objects, separating objects, smooth larger object boundaries without obvious area changes [9].

Morphological opening operation is firstly proposed to the original image in solder joint inspection process to weaken the narrow part and obtain the background image, as a) diagram shows in Fig. 4.Image subtraction processing to the original gray image and the background image gets the gray enhancement image, as shown in b) diagram. Binarization detection to the morphological enhanced image can achieve better detection of the solder joints, as shown in Fig. 5.


a）Background image   b）Image Enhancement
Figure 4 .Morphological Image enhancement

Figure 5. Binarization of solder joints

VI. DEFECT DETECTION OF SUBTRACTION METHOD

Background subtraction can provide the difference between images and can be used to guide the dynamic monitoring, moving target detection and tracking, image background elimination and image recognition etc[10]. It must make the image corresponding to the same target point, or geometric correction and matching must be first done. In the processing noise will be extracted and leaving only defect characteristics so as to achieve the purpose of identification and classification.
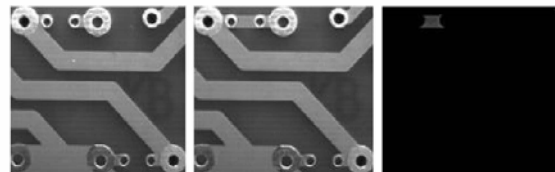
a) Detect Image   b)Template image   (c)Defect detection
Figure 6. Image detection of Subtraction Method

Fig. 6 is the defect detection image by subtraction method, and a) is the board image to be detected, b) is the template image，c) is the defect detection image by subtraction.

CONCLUSION

This paper analysis the binarization and defects detecting system of the printed circuit board based on image processing technology. The system is composed of image acquisition, image enhancement, edge detection ,image binarization and defects detection by subtraction method. The preprocessing and the morphological analysis is

compiled by MATLAB which provides a solid foundation for the online and fast detection of the quality of the printed circuit board. This method can perform high effective, fast speed and accurate measurement by the powerful digital image processing ability.

REFERENCES

[1] Xiong Zhenjiao. Research on the Detection Method Based on Image for Defect in Circuit Board. [M]. School of Information Engineering Nanchang Hangkong University, 2012.

[2] N.G.Shankar, Z.W. Zhong. Defect detection on semiconductor wafersurfaces[J].Microelectronic Engineering , 2005: 337-346.

[3] JIANG Ke-wan, WU Qi. Application of Image Recognition Technology in PCB Precision

[4] Xiong Bangshu, Xiong Zhenjiao, Mo Yan. Detection Method of Printed Circuit Board Defect

[5] S-J Ko, Lee Y H. Center Weighted Median Filter and their Application to Image Enhancement.

[6] Liu He. Digital image processing and application [M]. China Electric Power Press, 2005

[7] Zhao Chunhui. Modern Image Processing Technology and Matlab Realization[M]. Beijing: People' Posts And Telecommunications press, 2001.

[8] K.R.Castleman. Digital Image Processing. Newyork: Prentice Hall,1998.

[9] Bin He. Digital Image Processing [M]. Beijing: People' Posts And Telecommunications Press, 2001

[10] Zhou Jinping.MATLAB6.5 Image Processing and Application Examples[M]. Beijing: Science