Circuit Board Defect Detection Using Image Registration.

Priya Hankare[#1], Vihang Patil[#2], Dinkal Solanki[#3], Sahil Tikke[#4], Shashikumar Vishwakarma[#5]

[#]*Department of Electronics and Telecommunication, University of Mumbai*

[1]priya.h@somaiya.edu

[2]vihang.patil@somaiya.edu

[3]dinkal.s@somaiya.edu

[4]sahil.tikke.9977@gmail.com

[5]shashikumar.v@somaiya.edu

Abstract——A printed circuit board or (PCB) is used to mechanically support and electrically connect electronic components using conductive pathways, track or signal traces etched from copper sheets laminated onto a conductive substrate. The automatic inspection of PCBs serves a purpose which is traditional in computer technology. The purpose is to relieve human inspectors of the tedious and inefficient task of looking for those defects in PCBs which could lead to electric failure. We first compare a PCB standard image with a PCB image, using a simple subtraction algorithm that can highlight the main problem-regions. We have also seen the effect of noise in a PCB image that at what level this method is suitable to detect the faulty image. Finally, defect classification operation is employed in order to identify the source for six types of defects namely, missing hole, pin hole, under etch, short-circuit, mouse bite, and open-circuit.

Keywords: Image Subtraction; Thresholding; Image Registration; Printed Circuit Board

I. INTRODUCTION

Bare printed circuit board is a PCB without any placement of electronic components which is used along with other components to produce electric goods. In order to reduce cost spent on manufacturing caused by defected bare PCB, the bare PCB must be inspected. Performance of many electronic products is dependent on the quality of PCBs. Defects in PCBs are detected manually by inspectors. It is known that humans are bound to make mistakes during inspection. Manual inspection is slow and less consistent, whereas automatic inspection systems remove the subjective aspects and provide fast quantitative dimensional assessments. The automatic visual inspection is important because it removes the subjective aspects and provides fast and quantitative assessments.

PCB inspection process could be separated into two main stages: (1) The defect detection, and (2) The defect classification. In defect detection, it is not important to know the type of defects. But in defect classification, it is desired to know the type of the detected or identified defects. Defect classification will take place after the defect detection mechanism has been carried out.

Defect detection techniques can be classified into three major classes: (1) Reference based approaches, (2) Non-reference based approaches, and (3) Hybrid based approaches.

The reference comparison approach is based on a comparison between the image of the PCB to be tested and that of an ideal PCB which conforms to pre-defined design specifications. The non-referent method they do not need any reference pattern to work with, they work on the idea that the pattern is defective if it is not confirmed to the design specification standards. These methods are also called a design rule verification method. This paper utilizes a non-contact reference based, image processing approach for defect detection and classification and simple image processing algorithm for locating those defects on PCB board. A template of a defect free PCB image and a defected test PCB image are segmented and compared with each other using image subtraction and other procedures. Discrepancies between the images are considered defects and are classified based on similarities and area of occurrences.

II. RELATED WORK

Moganti et al. [2] proposed three categories of PCB inspection algorithms: referential approaches, non-referential approaches, and hybrid approaches. Referential inspection is performed by making a comparison between the template PCB image and tested PCB images. Non-referential approaches are based on the verification of the general design rules that essentially verify the widths of conductors and insulators. Lastly, hybrid approaches involve a combination both of referential approaches and non-referential approaches. These approaches have the advantages of the both of referential approaches and non-referential approaches, but at the expense of being more complex. These PCB inspection algorithms mainly focus on defect detection [2]. Based on this deficiency of defect detection, a defect classification operation is needed in PCB inspection. Therefore, an accurate defect classification

procedure is essential especially for an on-line inspection system during the PCB production process [3].

However, only Wu et al. [4], Heriansyah et al. [5], and Rau et al. [6] have proposed defect classification algorithms for PCB inspection. Wu et al. [4] developed a PCB defects classification method based on pixel processing. The method is divided into two stages: defect detection and defect classification. Heriansyah et al. [5] developed an algorithm using the advantages of artificial neural networks to correctly classify defective PCB patterns.

In this paper, a PCB defect classification algorithm is proposed. The proposed algorithm is developed to detect and classify six different printing defects, namely, missing hole,= pinhole, under etch, short-circuit, open-circuit, and mouse bite, using a combination of a few image processing operations such as image difference, image subtraction, image addition, etc. Even though a similar algorithm has been previously proposed [7], the applicability of the defect classification algorithm has been demonstrated solely based on computer-generated images. Hence, the difficulties of solving the alignment and uneven illumination issues have been ignored, and apparently, this is a limitation of these previous papers. In this study, a software-based image registration and the defect classification algorithm is implemented based on real PCB images.

III. TECHNOLOGY DESCRIPTION

The PCB inspection system developed in this research for detecting and classifying defects on PCB which includes six stages. The stages are image acquisition, image registration, defect detection, thresholding, filtering, and defect classification.

A. Image acquisition: The image of the Printed Circuit Board with no defects is loaded on to the computer. While capturing the image suitable light source is provided. The image captured is loaded on to the computer. This step means acquiring the image that is to be checked for defects which could be of various image formats such as bitmap (.bmp), portable network graphics (.png), JPEG (.jpg), etc. Another Template/Reference image of a defect free PCB is taken as input which could also be of the same or different image format. The function imread('Image_name.Image_format') is used for acquiring the image.

B. Image registration: Defective image is registered by software according to the template image. At first, geometric transformation will align the defective image to the template image. Geometric transformation method used for this study is based on an affine transform. An affine transform is a linear coordinate transformation that includes typical geometric transformations such as translation, rotation, scaling, stretching, and skewing.

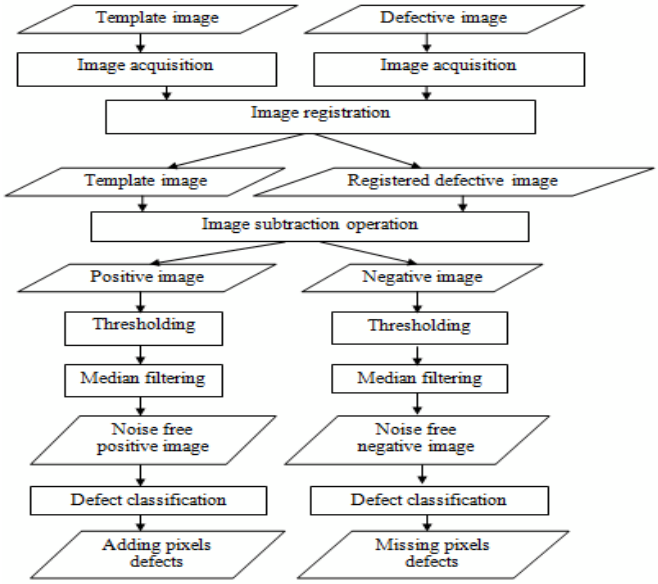


Fig no.1 FLOW CHART OF PCB DEFECT DETECTION

In image re-sampling, the image values in non integer coordinates are computed by the appropriate interpolation technique. In this study, a bi-cubic interpolation method has been employed for digital image transformation to detect image deformation over the entire image area.

C. Image Complement: The Image of the PCB which is to be tested is to be complemented for subtraction and defect detection. The complementing of a 3D RGB image has to be done with the help of converting the image to Grayscale and then complementing. The grayscale conversion is done with the help of function RGB2Gray ('Image_name.Image_ Format'). For Image complement each pixel value of the image is subtracted from 255.

C.1 Switch Case/Defect Classification: The user has to give the input for the defect he needs to test. Four types of defects have been covered in the project till now which are as follows:

C.2 Open Circuit: When a PCB micro strip line/bus line gets broken then the current/voltage cannot pass hence this type of defect is called as Open circuit since it creates an open circuit on the PCB causing infinite resistance.

C.3 Short Circuit: When two parallel micro strip lines get connected by improper etching process a short circuit gets created which gives undesired output. Hence this defect is called as Short Circuit.

C.4 Missing Pinhole: In a PCB pinholes are present to mount the electronic components on the PCB. Hence if the etching is

improper then there is a chance of missing pinhole which would cause ambiguity in placing components. Therefore this early detection of missing pinholes would help in discarding the ambiguity.

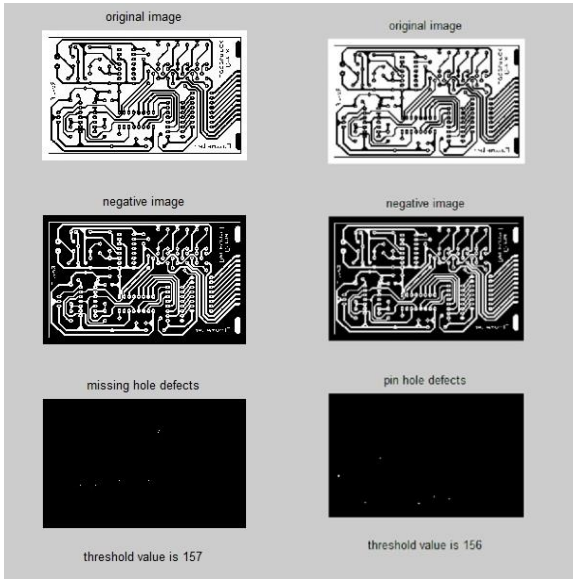
C.5 Pinholes: Just as there would be missing pinholes a case also may occur where an extra pinhole may cause ambiguity in placing the components. Hence the defect detection algorithm would provide simplifying the ambiguous pinhole detection.

D. **Thresholding**: After Selection of the Defects the Images are Threshold according to their size and shape. Thresholding makes the pixel below a Threshold value zero i.e. black and pixel having value above the threshold value white. Hence this operation makes it easier for the appearance of PCB tracks more visible in an image. The image which is to be tested and the template image are given same threshold value to reduce complexity of the program.

E. **Image Subtraction**: After Thresholding is done the next step is image subtraction i.e. subtraction of defective image from the template image. The subtraction is done pixel by pixel of the template and the defective image. Since in this part of the project we have assumed the image to be registered subtraction has become easier.

F. **Output**: The defects are seen as white spots in the resultant image caused by image subtraction operation. If no spots exist in the image it means that the PCB is not defective. If any spots are seen in the resultant image then defects exist in the image. The Classification of type of defects based on resultant image would be covered in the next part of the project.

IV. Implementation Results



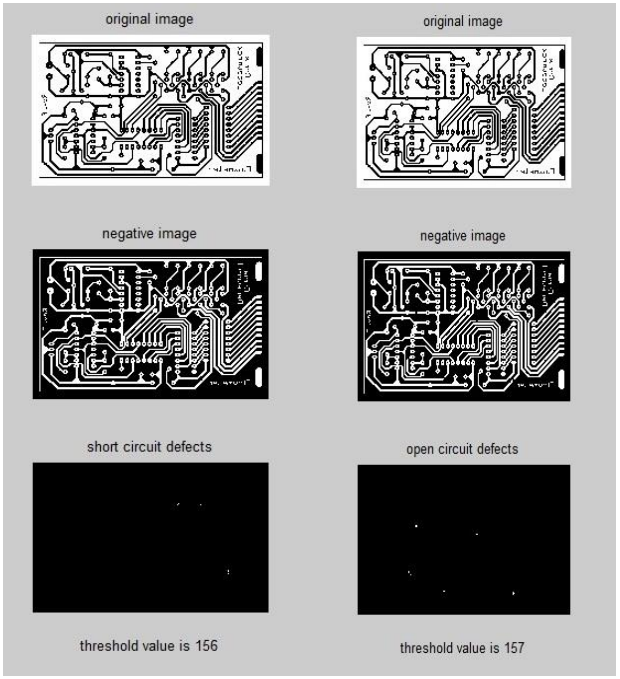


Fig no.2 Results of implemented algorithm

IV. Discussion

Based on the algorithms shown above, these algorithms need two images, namely master image and test image. At first, both images are subjected to image subtraction operation to produce a resultant image. Then, XOR operator is applied to template image and the defective image separately to produce resultant image

PCB quality testing is very important from the point of view of sales and ultimately success of the product. Our simulated work in this research gave rise to lots of useful insights. Especially, it is very clear now that using machine vision many of the defects on the PCB can be detected with good accuracy. Various advances take place in PCB manufacturing industry over the last decade.

This project can be further improved by upgrading defect detection algorithm to suit a variety of lighting conditions. Besides, we could improve the algorithm to detect different kind of defects such as missing components or short circuits. Improvement can be made on stating the location for the defect and calculate the size of the defect. Future work consists of inspecting and analyzing a PCB with Surface Mounted Devices.

References

.

[1] J. Hong, K. Park and K. Kim (1998), Parallel processing machine vision system for bare PCB inspection, *Proceedings of the 24th Annual Conference of the IEEE*, pp.1346-1350.

[2] M. Moganti, F. Ercal, C. H. Dagli and S. Tsunekawa (1996), Automatic PCB inspection algorithms: a survey, *Computer Vision and Image Understanding*, vol.63, no.2, pp.287-313.

[3] W. Y. Wu, M. J. Wang and C. M. Liu Chu (1996), Automated inspection of printed circuit boards through machine vision, *Computers in Industry*, vol.28, no.2, and pp.103-111.

[4] R. S. Guh and J. D. T. Tannock, A neutral network approach to characterize pattern parameters in process control charts, *Journal of Intelligent Manufacturing*, vol.10, no.5, pp.449-462, 1996

[5] R. Heriansyah and S. A. R. Abu-Bakar (2004), Defects classification on bare PCB using multiple learning vector quantization neural network paradigm, *International Conference on Computer Graphics, Imaging, and Visualization 2004 (CGIV 2004)*, pp.50-53.

[6[] H. Rau and C.-H. Wu, Automatic optical inspection for detecting defects on printed circuit board Inner layers, *International Journal of Advanced Manufacturing Technology*, vol.25, no.9-10, pp.940. 946, 2005