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PCB Defect Detection Using Image Subtraction Algorithm

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ABSTRACT

A Printed Circuit board (PCB) is used to connect different electronic components mounted on it using pathways or tracks which is etched from copper sheets. An automatic PCB defect detection is an approach that can be used to counter difficulties occurred in manual inspection that can eliminate subjective aspects and then provides fast quantitative and dimensional assessments. In this study different approaches have been implemented on reference and test PCB images to detect defects on bare PCBs before etching process, since etching usually contributes most destructive defect found on PCBs. We first compare a PCB standard image with the PCB test image using a simple subtraction algorithm that can highlight the main problem-regions. The defects that can be detected are over etchings (opens), under etchings (shorts), holes etc.

Keywords:- Printed Circuit Board, Image Subtraction, Threshold, Defect Detection.

I. INTRODUCTION

Bare printed circuit board (PCB) 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. It also relieves human operator from tedious, boring, and repetitive tasks of inspection. On the other hand, automatic systems do not get tired and are consistent. 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. The hybrid flaw detection method uses both referential and non-referential method and increases the efficiency.

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. LITERATURE SURVEY

Heriansyah proposed a technique, which uses referential pixel based approach, where the PCB defects could be formed into three groups: the defects on the foreground only, the defects on the background only, and the defects on both foreground and background (the defect is caused by interaction with other object). To classify the defects, the LVQ neural network has been selected as the classifier. The designed patterns are trained and tested using this neural network. For the neural network implementation, only two groups of defects will be used for training (i.e. the foreground and the background). For performance comparison, a pixel-based approach developed by Wu et al. was used. At the time of writing this paper, this was the only algorithm designed for defect classification.

The pixel-based approach could classify seven defects (short, missing hole, pinhole, open, nose-bite, spur, and etching problem). In this approach, there are few stages involved: segmentation, windowing (reference image and detected defects), defects detection, pattern assignment, normalization, and classification. For the neural network training part, since this process is done off-line, it does not affect the overall processing time.

These PCB inspection approaches mainly concentrated on defects detection (Moganti et al., 1996). However, defects International Journal of Computer Applications (0975 – 8887) Volume 87 – No.9, February 2014 41 detection did not provide satisfactory information for repairing and quality control work, since the type of detected defects cannot be clearly identified. Based on this incapability of defects detection, defect classification operation is needed in PCB inspection. Therefore, an accurate defect classification procedure is essential especially for an on-line inspection system during PCB production process. Human operators simply inspect visually against prescribed standards. The decisions made by them often involve subjective judgment, in addition to being labour intensive and therefore costly, whereas automatic inspection systems remove the subjective aspects and provide fast, quantitative dimensional assessments. Automated visual inspection is required because of the following criteria

- They relieve human inspectors of the tedious jobs involved.
- Manual inspection is slow, costly, leads to excessive scrap rates, and does not assure high quality.
- Multi-layer boards are not suitable for human eyes to inspect.
- With the aid of a magnifying lens, the average fault- finding rate of a human being is about90%. However, on multi-layered boards (say 6 layered), the rate drops to about 50%. Even with fault free power and ground layers, the rate does not exceed 70%.
- Industry has set quality levels so high that sampling inspection is not applicable.
- Production rates are so high that manual inspection is not feasible.
- Tolerances are so tight that manual visual inspection is inadequate.

A variety of approaches for automated optical inspection of printed circuit boards (PCBs) have been reported over the last two decades.

III. METHODS

A. Machine Vision

Machine vision is the science and technology of machines that "See". It is the science in which a computer is programmed to process and understand images and video. It can be assumed as signal processing applied to images, videos. Machine vision is concerned with the theory behind artificial systems that extract information from images and sequence of images. The image data can take many forms, such as video sequences, views from multiple cameras, or multi-dimensional data from a medical scanner. On a technical ground, it is necessary to implement the proposed theory and method to construct a machine vision system. Machine vision can be implemented for the system involving following processes. – Automated Inspection process – Process control – Data base collection and indexing – Modelling of system and environment.

B. Bare PCB Defects

There are some defects commonly found on PCB. Conductor breaking and short-circuit are characterized as fatal defects. Pinhole, breakout, Over etch, and under etch are characterized as potential defects. Fatal defects are those in which the PCB does not attend the objective they are designed for, and potential defects are those compromising the PCB during their utilization. During etching process, the anomalies occurring on bare PCB could be largely classified in two categories: the one is excess of Copper and the other one is missing copper. The incomplete etching process leaves unwanted conductive materials and forms defects like short, extra hole, protrusion, island, and small space. The excessive etching makes open, pin hole, nick (mouse bite), and thin pattern. In addition to the defects mentioned above, some other defects may exist on bare PCB, for example, missing holes.

IV. TECHNOLOGY DESCRIPTION

An arithmetic or logic operation between images is a pixel by-pixel transformation. It produces an image in which each pixel derives its value from the value of pixels with the same coordinates in other images.

If A and B are the images with a resolution XY, and Op is the operator, then the image N resulting from the combination of A and B through the operator Op is such that each pixel P of the resulting image N is assigned the value pn

= (pa) (Op) (pb); where pa is the value of pixel P in image A, and pb is the value of pixel P in image B.

Pixel (Image 1)	Pixel(Image 2)	Pixel(Output Image)
0	0	0
0	1	1
1	0	1
1	1	0

FIG.1 TRUTH TABLE FOR XOR OPERATION

V. PROCESS FLOWCHART

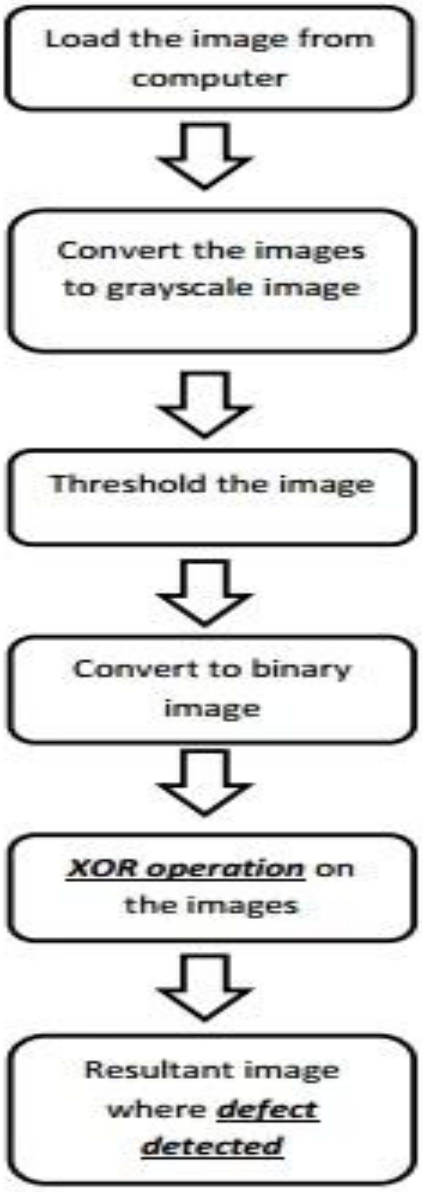

FIG 2 FLOWCHART

A. *Loading The Image*

The image of the Printed Circuit Board with no defects is loaded on to the computer. The Board which needs to be inspected is placed on the glass platform of suitable size. A camera is used in order to take the picture of the PCB. While capturing the image suitable light source is provided. The image captured is loaded on to the computer. Web camera functionality can be given to the 12mp camera or a direct cable connection can be given to the camera to capture the image of the Board mounted on the glass platform. Glass platform is used in order to ensure transparency since the camera will be placed below the platform. The image captured will be considered for the further steps.

B. *Converting to gray scale*

Instead of giving equal contributions to all the colours, in case of this context we have to decrease the contribution of red colour, and increase the contribution of the green colour and put blue colour contribution in between these two.

MASTER IMAGE TEST IMAGE

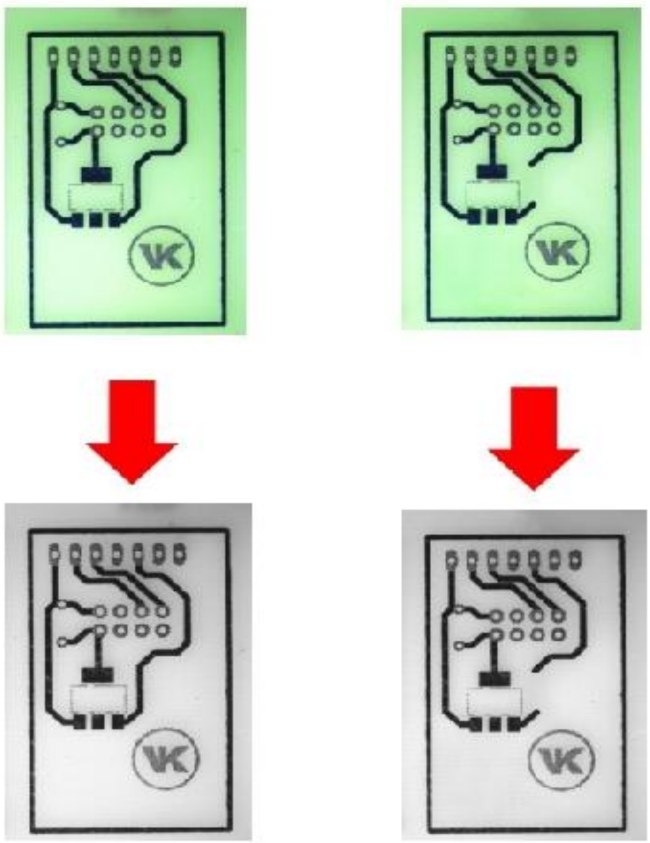

FIG.3 CONVERTING TO GRAY SCALE

C. *Thresholding*

It is useful to be able to separate out the regions of the image corresponding to the objects in which we are interested, from the regions of the image that correspond to background. Thresholding often provides an easy and convenient way to perform this segmentation on the basis of the different intensities or colours in the background or foreground regions of an image.

In addition it is often useful to be able to see what areas of an image consist of pixels whose values lie within a specified range or band of intensity. Input to a Thresholding operation is typically a gray scale or colour image. In the simplest implementation the output is a binary image representing the segmentation. Black pixels correspond to background and white pixels correspond to foreground (or vice versa). In the simple implementations the segmentation is determined by a single parameter known as the intensity threshold. In a single pass, each pixel in the image is compared with this threshold. If the pixels intensity is higher than the threshold, the pixel is said to, say white in the output. If it is less than the threshold it is said to be black.

Each pixel in the image is compared with threshold. If the pixels intensity is higher than the threshold, the pixel is said to, say white (binary 1) in the output. If it is less than the threshold it is said to be black (binary 0).

D. *XOR Operation*

The overview of the XOR/Subtraction operation process is shown below

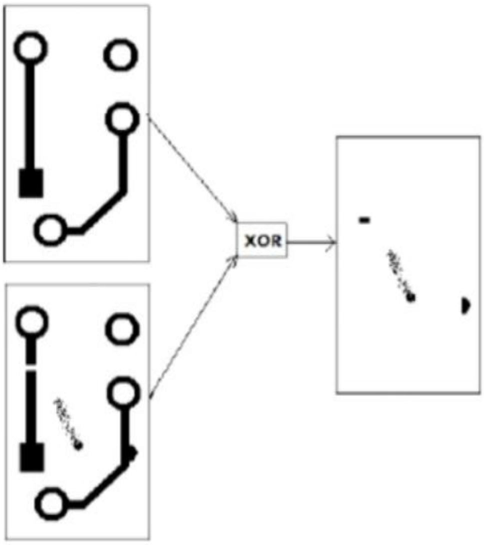

FIG.3 RESULTANT IMAGE

To perform the image subtraction operation, it is required that both images have same size in terms of pixels. The logical XOR operation will show us the defect in inspected image as compared with reference image.

E. *Resultant Image*

The resultant image obtained after comparing the image of the PCB with the master PCB image if defects are found,

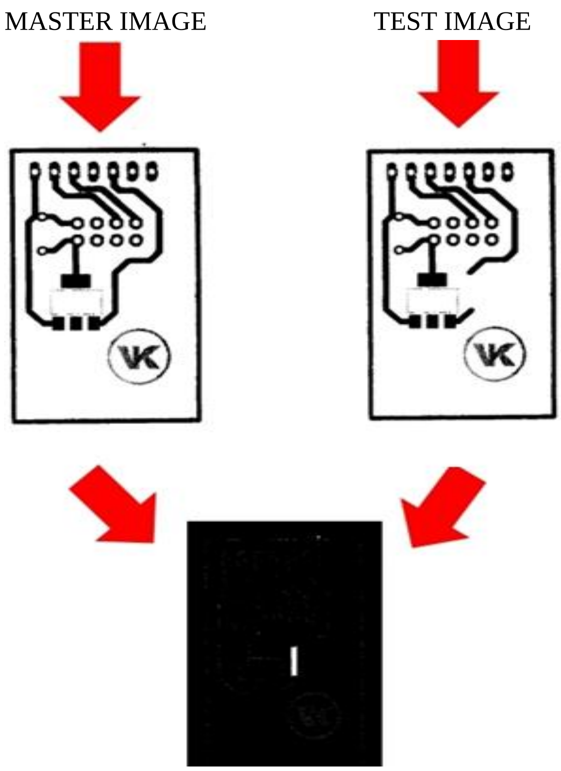

FIG.4 COMPARING REFERENCE AND TEST IMAGE (DFECTS FOUND)

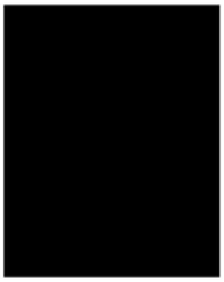

FIG.5 RESULTANT IMAGE(DEFECTS NOT FOUND)

VI. RESULTS AND 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 as shown in figure 4 and figure 5.

VII. CONCLUSION AND FUTURE WORK

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. Machine vision may answer the manufacturing industry's need to improve product quality and increase productivity.

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 analysing a PCB with Surface Mounted Devices.

REFERENCES

[1] S. H. Indera Putera, Syahrul Fahmi Dzafaruddin, Maziah Mohamad, "MATLAB Based Defect Detection and Classification of Printed Circuit Board" Digital Information and Communication Technology and it's Applications (DICTAP), IEEE 2012 Second International Conference. Bangkok.

[2] S. H. Indera Putera and Z. Ibrahim „Printed Circuit Board Defect Detection Using Mathematical Morphology and MATLAB Image Processing Tools‟, ICINT 2010, Shanghai, China, 2010.

[3] IJSSST, Vol. 9, No. 2, May 2008, ISSN: 1473-804x] N. K. Khalid, Z. IBRAHIM, M. S.Z. ABIDIN "AN ALGORITHM TO GROUP DEFECTS ON PRINTEDCIRCUIT BOARD FOR AUTOMATED VISUAL INSPECTION."

[4] N.K. Khalid. 'An Image Processing Approach Towards Classification of Defects on Printed Circuit Board', Projek Sarjana Muda, Universiti Teknologi Malaysia, 2007.

[5] M. Moganti, F. Ercal, C.H. Dagli, and S. Shunekawa, 'Automatic PCB Inspection Agorithm: A Survey', 1996, 63. No. 2. [4] T. Taniguchi, D. Kacprzak, S. Yamada, M. Iwahara, and T.Miyogashi, 'Defect Detection on Printed Circuit Board by using Eddy-Current Technique and Image Processing', 101 Press, 2000

[6] Ajay Pal Singh Chauhan, Sharat Chandra Bhardwaj, "Detection of Bare PCB Defects by Image Subtraction Method using Machine Vision", Proceedings of the World Congress on Engineering 2011 Vol II WCE 2011, July 6 - 8, 2011, London, U.K., ISBN: 978-988-19251-4- 5,ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

[7] Sanveer Singh, Manu Bharti "Image Processing Based Automatic Visual Inspection System for PCBs" IOSR Journal of Engineering (IOSRJEN) ISSN: 2250-3021 Volume 2, Issue 6 (June 2012), PP 1451-1455.

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

[9] 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.

[10] Horng-Hai Loh, Ming-Sing Lu, "Printed Circuit Board Inspection Using Image Analysis," IEEE Transactions on Industry Applications, vol. 35, no. 2, pp. 426-432, 1999.

[11] Ismail Ibrahim , March 2012," A printed circuit board inspection system with defect classification capability", International Journal of Innovative Management, Information & Production ISME 2011 ISSN 2185-5439 Volume 3, Number 1.

[12] Ibrahim Z and Indera Putera S.H, (2010) “Printed Circuit Board Defect Detection Using Mathematical Morphology and MAT LAB Image Processing Tools “IEEE 2nd International Conference on Education Technology and Computer (ICETC)

[13] H. Ng., 2007,” Automatic Thresholding for defect detection.” Pattern Recognition Letters, 27:1644–164s.