PCB INSPECTION SYSTEM USING IMAGE PROCESSING

Namita Kalyan Shinde, Prof.S.S.Morade

***Abstract*— It is important to produce a zero-defect PCB. This is to ensure a high quality PCB that translates to reliable and quality digital end products An automated visual printed circuit board (PCB) inspection is an approach used to counter difficulties occurred in human's manual inspection that can eliminates subjective aspects and then provides fast, quantitative, and dimensional assessments. Various concentrated work on detection of defects on printed circuit boards (PCBs) have been done, but it is also crucial to classify these defects in order to analyze and identify the root causes of the defects. This project proposes a PCB defect detection and classification system. Using Image subtraction algorithm for the template PCB image and PCB image which is to be inspected, we find out defects in the PCB. To get the details about the defects, extracting the structural features based on the regional properties such as perimeter, regional areas, orientation etc.**

***Index Terms*— PCB Defect detection, Thresholding, Image Subtraction, Feature extraction.**

I. INTRODUCTION

A bare printed circuit board (PCB) is a PCB that is used before the placement of components and the soldering process. It is used along with other components to produce electronic goods. During the manufacturing of printed circuit boards, widths of insulators and conductors can change because of manufacturing defects such as dust, over etching, under etching, and spurious metals. Etching is the process, where the copper board will undergo 'peeling' process, where the circuit layout will be preserved while the rest of the copper background will be washed out. In order to minimize scrap caused by the wrongly etched PCB panel, inspection has to be done in early stage. To reduce manufacturing costs associated with defected bare PCBs, the inspection of bare PCBs is required as the foremost step of the manufacturing process. This project is motivated mainly by the need for more efficient techniques in inspection of the PCB panel in PCB fabrication process. Normally, a couple of operators are assigned in each station to manually check the PCB panels. This technique is not economical in a long run as it takes many man hours. In addition, humans are prone to making errors especially due to fatigue. Moreover, it is impossible to check the entire PCB panels at every location without any delay. Instead, the printed laminate is sampled a certain interval of quantity for manual inspection. As the electronic circuitry technology advances, the PCB pattern becomes denser and complicated to facilitate smaller end products. Thus, manual inspection is not applicable anymore. Meanwhile, the advances in computers in term of high speed, large memory with low cost have resulted in better and cheaper equipment for image processing. Hence, there exist a possibility of introducing and implementing an automated PCB inspection system to remove the subjective aspects of manual inspection. At the same time, the automated PCB inspection system provides real time assessment of the PCB panel.

PCB defects can be categorized into two groups: Functional defects and cosmetic defects. Performance of the PCB gets affected by the functional defects. Cosmetic defects affect the appearance of the PCB, but can also jeopardize its performance in the long run due to abnormal heat dissipation and distribution of current [1]. However, in a long period, the PCB will not perform well since the improper shape of the PCB circuit pattern could contribute to potential defects. Thus, it is crucial to detect these two types of defects in the inspection phase. Figure 1(a) shows an artificial defect-free PCB image pattern [2]. Figure 1 (B) shows the same image pattern as in Figure 1 (A) with a variety of defects on it. The printing defects and anomalies that will be looked at, for example, are breakout, short, pin hole, wrong size hole, open circuit, conductor too close, under etch, spurious copper, mouse bite, excessive short, missing conductor, missing hole, spur and over etch. These defects are shown in Figure 1 (B).

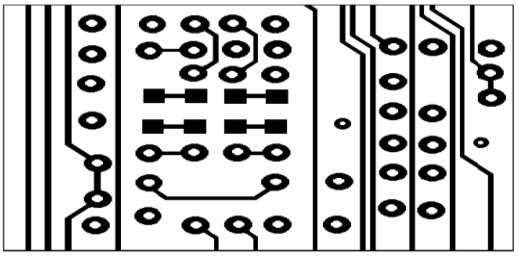

Figure 1 (A): An Example of Good PCB Patterns

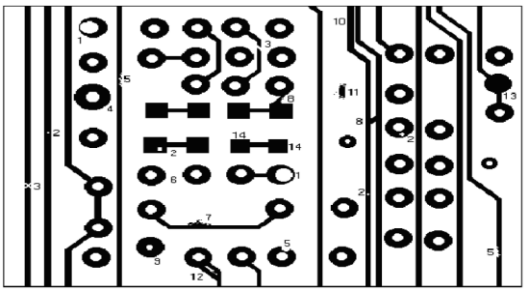

Figure 1 (B): An Example of Defective PCB Patterns

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1.breakouts 2.Pin hole 3.open circuit 4.under etch 5.mouse bite 6.missing conductor 7.spur 8.short 9.wrong side hole 10.conductors too close 11.spurious copper 12.excessive short 13.missing hole 14.overetch

II. LITERATURE REVIEW

Numerous PCB inspection algorithms have been proposed in the literature to Moganti [3] divided the PCB inspection algorithms into three main categories: reference comparison (reference-based) approach, design-rule checking (non-referential) approach and hybrid approach which involved a combination of reference comparison and design-rule approach.

Comparison technique consists of comparing both images using XOR logic operators (also called image difference operation). It is based on the assumption that, any difference between the reference and the test image is considered as a defect. The operation is simple but the main constraint found in this image comparison technique is on achieving a precise alignment of the reference PCB and the test PCB for image registration. Instead of XOR logic operator, image mathematical operation is also useful. For instance, the work carried out by Wen-Yen, [4] did the direct subtraction of the reference to the test image to produce Positive (P), Negative (N) and Equal (E) pixels. Defects detected on P and N pixels. After that, defect classification is done based on P, N and E pixels. Other method utilizes the features extracted from both the reference and the test PCB image. The features of a PCB image can be extracted in a different way. Hara [5] extracted the features of boundary lines and small line-width patterns by using 2 types of extraction operators. Next, these features will be compared to identify the defects.

Model-based methods begin with conversion of images into a predefined model before inspection execution takes part based on the model. An early proposal use graph-matching technique. Under this technique, the defective PCB image can be successfully recognized but the position of each defect cannot be located. The major difficulty of this method is related to the matching complexity. Ja and Suk [6] introduced tree representation scheme of PCB image. Although the tree representation technique is less complex than graph-matching technique, yet the position of the defects still cannot be retrieved. Another model-based method compares two PCB images based on their connectivity [7] but the connectivity defects are limited to missing hole, short circuit or excessive short and open circuit only. The latest work of reference-based approach is carried out by Nam-Hyeong. They design a PCB inspection system can detects the defects on the test image based on the stored reference image by matching them using image difference operation. Block matching is performed to solve the misalignment between the two PCB images. Pre-processing such as thresholding, dilation and decision making is applied to the difference image in order to detect open and short defects. The inspection system is claimed as a significantly faster system when compared to the existing techniques but a lot of work should be done if the same system is going to be implemented to detect more defects, rather than open and short defects.

Heriansyah et al. [R Heriansyah 2012] have designed a technique that classifies the defects that may appear on the PCB using neural network. The algorithm segments the image into basic primitive patterns, enclosing the primitive patterns; patterns assignment, patterns normalization, and classification were developed using binary morphological image processing and Learning Vector Quantization (LVQ) neural network. In this approach for training and testing the neural network, 11 Defective patterns have been designed. The designed pattern was in 8 x 8 pixels size, with binary format. The PCB defects can be formed into mainly three groups as defects on foreground, background and on the both. For this classifier is needed so LVQ neural network has been selected as the classifier has been selected as a classifier. Then patterns which are designed previous are trained as well as tested using the neural network. For this network implementation, only defects classified in two groups 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, mouse-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.

III. SYSTEM OVERVIEW

There are a few steps to detect defect of bare PCB using Image Processing. First of all, the system should collect PCB images through camera. Then it has to enhance and binarize the image. After special image recognition and analysis process, the images should be compared with the templates, thus the common defects such as short circuit, open circuit ,burrs, defects and voids and other defects can be found out precisely. Finally the recognition results will be acquired and reported. Figure 2 shows the block diagram of proposed method. The hardware structure is shown in figure2. Under the control of the computer, the PCB delivering components automatically move the given PCBs. Image acquisition and moving control subsystem receives the central computer's control commands, acquires the PCB images real-timely and preprocesses them using MATLAB. The result data will be sent to the central computer.
Central computer is the core of the system. On the one hand, it controls the action of the delivering units and the image acquisition units. On the other hand, it needs to receive image data, processes the data, finds out the defect and outputs the detection report

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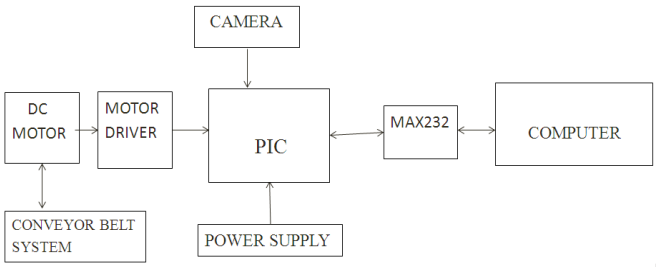

Figure 2: Block Diagram Of The System

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A. . Image Acquisition

The process of selecting the image and giving to system as an input is called image acquisition. I am using webcam for this purpose. The camera used is webcam of model no.IT306WC. Quality of acquiring image is one of key technology depends on camera. When the camera devices are determined, it is crucial to provide proper illumination approaches to ensure image quality. When extracting images, the luminary intensity and the stability of the auxiliary light source have great impacts on the image quality there are three kinds of camera data transmitting modes: USB, Camera Link, Gigabit Ethernet ports. We have used USB cable. The PCB image resolution is usually greater than 600dpi, which mean that the 10 mil width wire of PCB just occupies more than 6 pixels in the image. Images captured by camera are RGB form, so it has to convert in gray scale as it is necessary for image preprocessing.

Following flow chart shows the flow of the image processing part of the system**.**

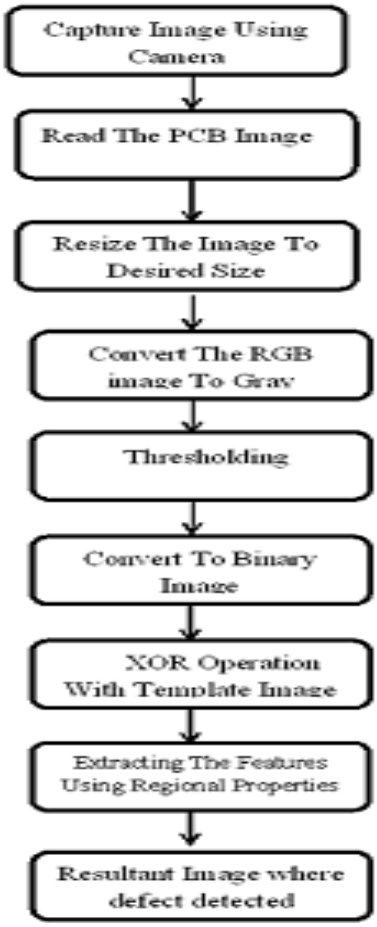

Figure 3: Flow Chart Of The System

B. Image Processing

Preprocessing of image is essential step to increase accuracy of total processing part. Image which captured by given camera is in RGB format. To mitigate the influence of inconsistent colors, we first convert all color face images into gray scale, as it is necessary for further processing part. Then resizing the image according to desired needy area. After this Image enhancement is necessary to enhance the edges. For enhancement we use histogram equalization. Because of enhancement, image shows dense wire and edges area becomes clear.

After this Thresholding of the image will have to do thresholding is a method to convert a gray scale image into a binary image so that objects of interest are separated from the background. In the PCB inspection system, the trace pattern of the PCB is segmented as objects of interest by the thresholding method.

The Thresholding algorithm involves simply setting all pixel values to a value of zero or one depending on whether the gray level at each pixel is greater than or less than a threshold. The difficulty with this method is to select an optimal threshold value. Especially when the area scan camera is used, it is very hard to acquire images of uniform intensity due to the characteristics of the lighting source and camera lens. Binary image ready for image subtraction algorithm.

C. Image Subtraction Algorithm

1) Image subtraction operation

A new image is obtained which is normally a result of the difference between the pixels in the same selected location of the two input images which being subtracted. Image subtraction is mostly used for change detection C=A-B; i.e. Maximum value of A-B and Zero

2) Image difference operation

Resultant new image is obtained by comparison of both images pixel-by-pixel by XOR logic operator. This operation is also called as image comparison operation

3) Complement operation

Complement operator is normally used to change the image from black to white and vice-versa.in complement of Binary image zeros valued pixels become ones value and ones valued pixels become zeros black pixel and white are reversed.

D. Feature Extraction

To get the more information regarding defects we use geometrical properties to extract structural features. We extract Structural features based on regional properties. Such as:

Regional Area: It is defined as ratio of the total number of the pixel in the skeleton to the number of pixels in the image.

Perimeter: It is the distance surround the boundary of the region of the defect. ‘regionprops’ is used to computes the perimeter by calculating the distance between each adjoining pair of pixels around the border of the region. If the image contains discontinuous regions, ‘regionprops’ gives the unwanted result that means then it shows the defect.

By extracting the structural features based on this regional properties will give the detailed information about the defects.

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IV. CONCLUSION

This article provides a design of PCB automatic defect detection system based on image processing technology. This design is a non-contact, fast, accurate and highly effective detection. This PCB defects detection technology which can not only detect open circuit and short circuit, but also can detect wire gaps, voids, scratches defects etc. For further improvement extracting the structural features based on these regional properties gives the detailed information about the defects

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