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PCB Defect Detection Using Image Processing

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ABSTRACT – Printed Circuit Boards are by far the most common method of assembling modern electronic circuits. During the manufacturing of PCB many defects are introduced which are harmful to precision circuit performance. The importance of the Printed Circuit Board inspection process has been magnified by requirements of the modern manufacturing environments where delivery of 100% defect free PCBs is the expectation. To meet such expectations, identifying various defect and their types becomes the first step.Human inspection is not productive and may introduce subjective aspects. Hence, Automated Inspection becomes critical in order to assure desired performance. Introducing and implementing a PCB inspection system using image processing to remove the subjective aspects of manual inspection. The basic technique of the proposed system is to detect the defect based on the digital image of the PCB using image processing techniques.Typical defects that can be detected are over etchings (opens), under-etchings (shorts), holes, missing components etc.

Key Words: PCB, Image Processing, Automated Inspection

I. INTRODUCTION

A Printed Circuit Board mechanically supports and electrically connects electronic components using conductive tracks, pads and other features etched from one or more sheet layers of copper laminated onto and/or between sheet layers of a non-conductive substrate. Printed Circuit Boards are used in nearly all electronic products and in some electrical products, such as passive boxes.The PCB (printed circuit board) manufacturing is becoming more and more important as the consumer electronics products, such as mobile phones, tablet PCs, automatic washing machines and so on, are indispensable for our everyday life.During manufacturing of PCB, many defects are generally introduced that might affect the performance of the board.The top three defects accounting for up to three quarters of all defects (according to industry statistics) are open circuit, short circuit and component shift.Visual inspection is generally the largest cost of PCB manufacturing. It is responsible for detecting both cosmetic and functional defects and attempts are often made to ensure 100% quality assurance for all finished products. There are three main processes in PCB inspection: defect detection, defect classification and defect location. Currently there are many algorithms developed for PCB defect detection and classification using contact or non-contact methods. Contact method tests the connectivity of the circuit but is unable to detect major flaws in cosmetic defects such as mouse-bite or spurious copper and is very setup-sensitive. Any misalignment can cause the test to fail completely. Non contact methods can be from a wide range of selection from x-ray imaging, ultrasonic imaging, thermal imaging and optical inspection using image processing. In a non-contact reference based, image processing approaches 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. This project 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. After obtaining patterns concerning the results these are located on the PCB.

II. OBJECTIVE

The objective of this project is to provide an inexpensive and comprehensive PCB defect detection technique that can detect major defects such as short circuit, open circuit, missing

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components etc. and to locate the defected region so as to avoid further malfunction.

III. METHODOLOGY

The basic algorithm proposed in this project involves image subtraction using XOR operation. The procedure from acquiring the image to detecting and locating the defects in demonstrated using the below flowchart.

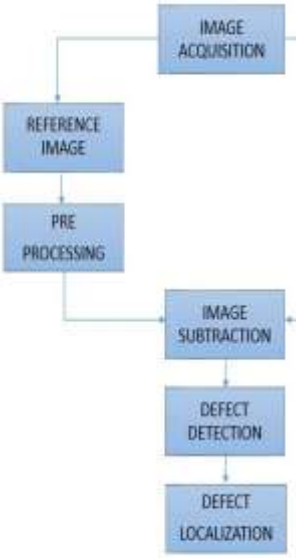

Fig 1: Flow chart of proposed system

The above diagram describes the process that takes during the working proposed system.

i. Image Acquisition: This is the first step in the defect detection process. It involves acquiring the image that is to be checked for defects. This is achieved using Pi Camera Module. Another Template/Reference image of a defect free PCB is taken as input which should be of the same image format.
ii. Pre-processing: Some pre-processing work needs to be done before going for subtraction to get desired results. The template and defective images may have different orientation and size, hence images are registered before the image operations. The pixels of both images are mapped according to their similar features in the image. For a rotated image the angle of rotation is calculated and the image is then re-rotated and resized for registration.After this, both the images are converted from RGB or greyscale format to binary format using a threshold value. Image threshold makes the pixel below a threshold value zero i.e. black and pixel having value above the threshold value white.
iii. Image Subtraction: This is the most important step in defect detection process. The image of the PCB is subtracted from the template image to check any dissimilarities. The output of this step produces an image having only dissimilarities from the two images. Regions having dissimilarities can be considered as defected regions.
iv. Defect Localization: Object localization in image processing refers to identifying the location of one or more objects and drawing abounding box around their extent. The output of image subtraction step is an image having only defects. These defects should be located in the original PCB image.

IV. FUNCTIONAL PARTITIONING

The proposed system is demonstrated in the following fig.1. The setup consists of Raspberry Pi, Camera module and a display device. The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse.The Pi camera module is a portable light weight camera that supports Raspberry Pi. It communicates with Pi using the MIPI camera serial interface protocol.
The software tool used for image processing is Python OpenCV (Open Source Computer Vision Library). It is a library of programming functions mainly aimed at real time computer vision. OpenCV-Python makes use of Numpy, which is a highly optimized library for numerical operations with a MATLAB-style syntax.

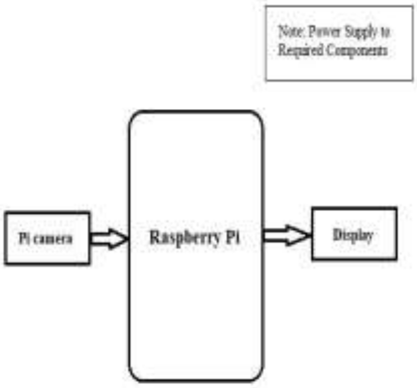

Fig 2: Block diagram of proposed system

V. OUTCOME

The result of defect detection is shown using a demo PCB image.

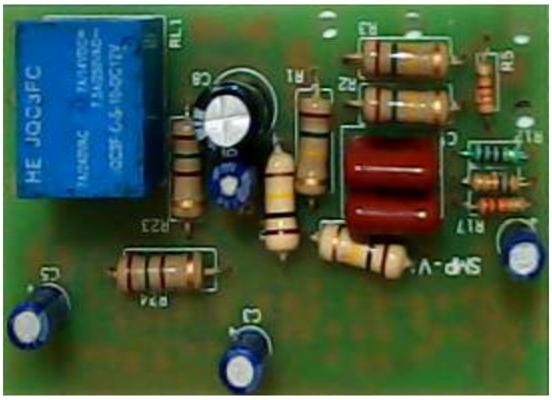

Fig 3: Reference defectless PCB Image

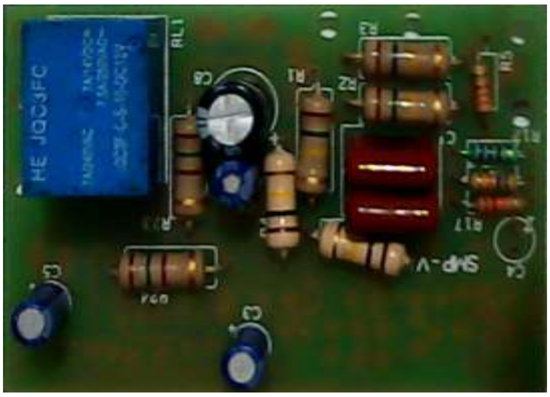

Fig 4: Test PCB Image

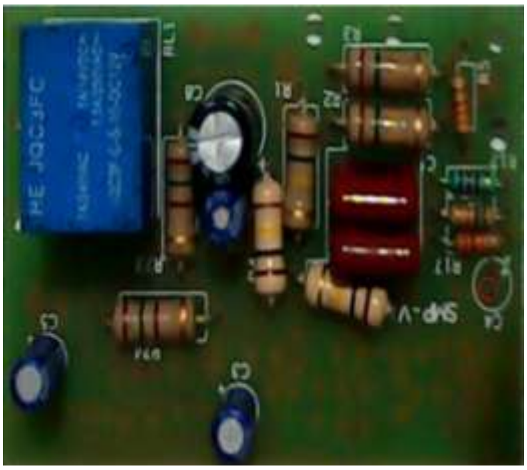

Fig 5: Final result showing a missing component in the Test Image (highlighted using red circle)

VI. ADVANTAGES

- The system removes subjective aspects of human inspection
- Reduces manufacturing cost by detecting defects during the early stages
- Works accuratelyon RGB images

VII. CONCLUSION

As a conclusion, the proposed system can be implementedusingOpenCV and can be used on bare PCBs to identify most types of defects caused during etching process. Detecting defects in the early stages reduces the manufacturing cost significantly. It can be also used after fabrication to check errors such as missing components. The system works well both on grayscale as well as RGB images. However, unwanted noises can occur during RGB to binary or grayscale to binary conversion. It may affect the system performance. Hence it is necessary to deal with the noises in order to get proper results.Our technique shows that it is feasible to use the software and detect the errors present in PCB so that further malfunction can be avoided during mass production.

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