ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

Volume 3, Special Issue 3, March 2014

2014 International Conference on Innovations in Engineering and Technology (ICIET'14)
On 21st & 22nd March Organized by

K.L.N. College of Engineering and Technology, Madurai, Tamil Nadu, India

Online Inspection of Printed Circuit Board Using Machine Vision

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I. INTRODUCTION

In 1997, the International Electrical and Electronics Engineering (IEEE) approved the PCB inspection based on the comparison of the **ABSTRACT—** Discrete wired connections can be reduced in size into printed circuit board (PCB). PCB manufacturing involves various steps such as patterning, etching, drilling, masking and legend printing. During the manufacturing process of PCB hardware, the short circuits between tracks and pads, discontinuity of track and various defects may occur. This paper presents a novel technique for identification of such defects using machine vision and image processing techniques. This system reduces the time of inspection and increases the accuracy, even though the image scale varies with respect to the reference image. The constant stand of distance between the camera and PCB need not be maintained. The result of applying this technique into PCB layout and real images are shown.

KEYWORDS— PCB inspection, Scale variant, Machine Vision, short circuited, tracks cuts.

connected table of a reference and a test image which described the method and its implementation of standard morphology image processing techniques [1]. To eliminate or to reduce the noise during the processing of defect identification, point to point image subtraction is used. Positive and negative images are generated and noise removal process is applied separately [2].To detect the defect presented in the PCB inner layers, fuzzy reasoning concept can be used. Image preprocessing is implemented to reduce the noise presented in the image. Image subtraction and boundary analysis techniques are applied to identify the defects [3].During image processing, misclassification error occurs, which can be reduced by evaluating the performance of thresholding algorithms. In this method, wrongly assigned pixels can be identified and filtered by choosing best thresholding algorithm [4]. Patterning is the initial process of PCB manufacturing. While patterning the PCB, images are captured using proper light settings. Image subtraction can be performed and defect can be identified [5]. Template is generated from the non-defected PCB and the template matching is performed with the defected PCB. So this defect can be identified. Missing and misaligned components are also inspected before the electronic test of the assembled PCB. The above nondestructive tests are performed and the defects are identified without any power supply given to the assembled PCB [6]. Machine vision is one of the advanced techniques which can explain about various lighting techniques for various applications, interfacing and data communication of various frame grabbers, industrial camera systems, lenses, camera calibration, and optical systems. Various lighting techniques are used to capture the image which is chosen based on the application. Front lighting is used to know about the surface information presented in the image. Back lighting is used to get the profile information presented in the image. It describes about various data cables with standard connectors. This work describes the reference image which is developed from the PCB layout file, the lighting technique which is used to acquire the PCB image, various noise reduction techniques using structuring elements, 2-D order-statistic filters and image processing algorithms to identify the short circuit between the tracks, pads and track cuts. For this purpose, numbers of connected components are used to identify the number of individual connections. Holes are separated and centroids are found from the holes presented in the acquired image and pixel list of connected components are sorted and checked whether the centroids are presented in the pixel list. Based on the connectivity result of the above steps, a connectivity matrix is generated for both PCB layout image and captured image. Both matrices are compared to identify the track short or track cut.

II. METHODOLOGY

A. Preprocessing the PCB Layout

PCB layout file consists of many layers which are converted into gerber file. Fig.1 shows the copper bottom layer of the gerber file generated using PCB designing software. The copper bottom layer is separated and is converted into an image file. The drilling holes sizes for various components are predefined. According to that, holes are modified in the image file. Fig.2 shows the image of an increased drill size and mirrored image.

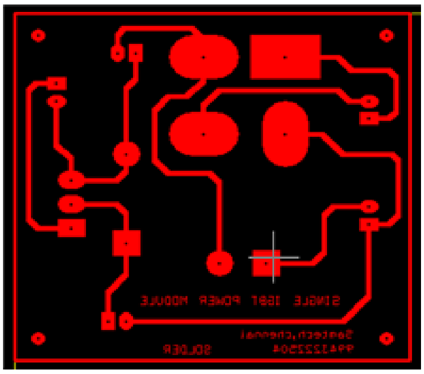


Fig. 1 Copper bottom layer of the gerber file.

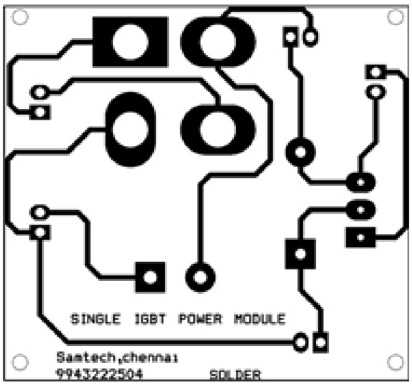


Fig. 2 Image of increased hole size and mirrored.

B. Image Acquisition Setup

Image acquisition is done using back lighting technique which is a white light and ambient light is made to null. So that the profile information about the region of interest (ROI) presented in the PCB gets clear. ROI is a copper area which is in the form of tracks and soldering pads. An image is previewed and acquired using software. Fig.3 shows, the block diagram of image acquisition setup. A high resolution industrial camera is used to acquire the image.

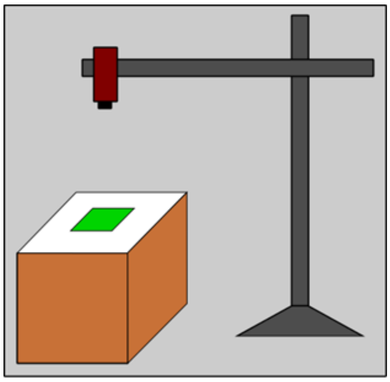


Fig. 3 Image of increased hole size and mirrored.

C. Preprocessing of the Acquired Image

An acquired defect image is a RGB image which is converted into gray level image that is shown in the fig.4. These images are converted into binary image by assigning proper thresholding value shown in fig 5.

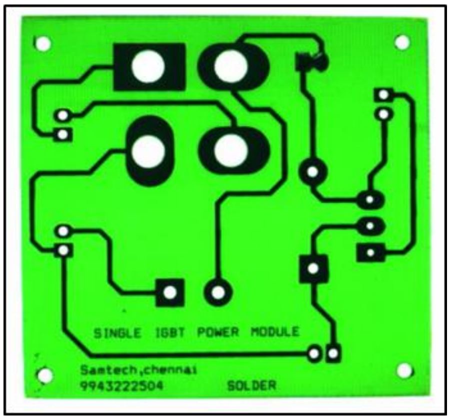
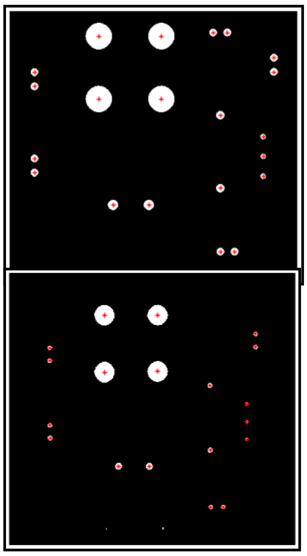


Fig. 4 Acquired Image with defect.

Fig. 5 Binary image with defect

D. Image Analysis

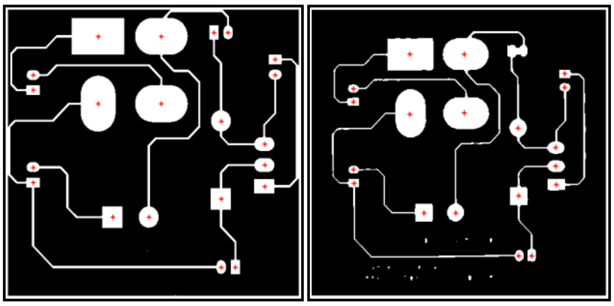
From the binary image, the holes are separated and the centroids are found for both (a) PCB layout (21 centroids) and (b) acquired image (19 centroids) as shown in fig.6. The number of centroids in both images differs due to the defect. [X Y] positions of the centroids are separated. Pixel list of both images are generated.



(a) (b)

Fig. 6 Holes with centroids (a) PCB layout (b) Defected PCB images

Fig.7 (a) Shows the connected components (8 components i.e. tracks) with centroids (21 centroids) in the PCB layout and (b) Shows the connected components (8 components i.e. tracks) with centroids (19 centroids) in the defected PCB images.



(a) (b)

Fig. 7 Connected components with centroids (a) PCB layout (b) Defected PCB images

III. RESULTS AND DISCUSSION

Co-ordinates of every centroid can be one of the pixels in the connected component pixel list. Based on the presence of the pixel, matrix is generated. Number of ones presented in rows represents the number of connected components and the number of ones presented in the column represents the presence of number of centroids in the same connected component. Table I shows the matrix generated from PCB layout image which has 8 rows and table II shows the matrix generated from defected image.

TABLE I
Matrix generated from PCB layout image

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	**1**	0	**1**	0	0	0	0	**1**	0	0	0	0	0	0
2	**1**	**1**	0	0	0	0	0	0	0	0	0	0	0	0
3	**1**	0	0	0	0	**1**	0	0	0	0	0	0	0	0
4	**1**	0	0	**1**	0	0	0	0	0	0	0	0	0	0
5	**1**	0	0	0	**1**	0	0	0	**1**	0	0	0	0	0
6	**1**	0	0	0	0	0	**1**	0	0	0	**1**	0	0	**1**
7	**1**	0	0	0	0	0	0	0	0	**1**	0	**1**	0	0
8	**1**	0	0	0	0	0	0	0	0	0	0	0	**1**	0

TABLE II
Matrix generated from PCB layout image

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	**1**	0	**1**	0	0	0	0	**1**	0	0	0	0	0
2	**1**	**1**	0	0	0	0	0	0	0	0	0	0	0
3	**1**	0	0	0	0	**1**	0	0	0	0	0	0	0
4	**1**	0	0	**1**	0	0	0	0	0	0	0	0	0
5	**1**	0	0	0	**1**	0	**1**	0	0	**1**	0	0	**1**
6	**1**	0	0	0	0	0	0	0	**1**	0	**1**	0	0
7	**1**	0	0	0	0	0	0	0	0	0	0	**1**	0

Both matrices are compared; obviously there is change in no of rows and no of columns and also in the position of ones which are misplaced. From this, the defected track can be identified and highlighted. Fig. 8. Shows the defect highlighted image.

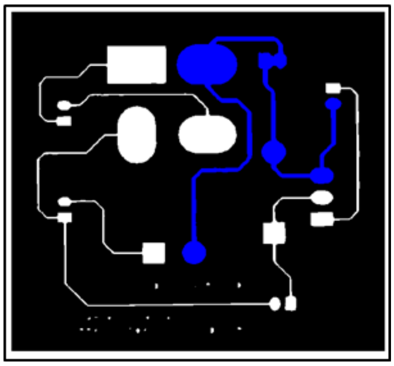


Fig. 8 Defect highlighted image.

IV. CONCLUSION

For online inspection of PCB, a novel algorithm has proposed and implemented using machine vision and image processing techniques. The algorithm has discussed in detail and the result is shown. In spite the scale of images is varied, this method increases the accuracy of the inspection at a fast manner. To implement this algorithm in an industrial application, some automated systems need to be carried out. Future work consists of inspecting the assembled PCB for missing and misaligned components.

ACKNOWLEDGEMENT

The authors would like to thank Assistant Professor R.Senthilnathan, Mechatronics, SRM University for his continuous moral support throughout this work.

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