Automatic Detection of PCB Defects

Ashish Singh  
PG Student  
ECE Department  
Silver Oak College of Engineering & Technology,  
Gujarat Technological University  
Ahmedabad, India.

Vimal H. Nayak  
Assistant Professor  
ECE Department  
Silver Oak College of Engineering & Technology,  
Gujarat Technological University  
Ahmedabad, India.

Mohammed G. Vayada  
Assistant Professor  
ECE Department  
Silver Oak College of Engineering & Technology,  
Gujarat Technological University  
Ahmedabad, India.

Abstract

A Printed Circuit Board (PCB) is everywhere from a small toy to a big electronic machine which we used in our daily life. PCB consists of circuit with various electronic components mounted on surface. PCB manufacturing consists of three stages in which inspection of PCB necessary to reduce the defects. First is printing, second is component fabrication over PCB surface and third is the component soldering. In this paper the automatic machine inspection using the different algorithm is discussed mainly subtraction algorithm. In this algorithm we will compare an Ideal image with the Test image in which the defect needs to be detected like missing hole, pin hole, underetch, short-circuit, mousebite, open-circuit etc.

Keywords: Machine vision, PCB defects, Image subtraction, Defect detection.

I. INTRODUCTION

The technology of computer vision has been highly developed and used in several industry applications. One of these applications is the automatic visual inspection of printed circuit boards (PCB). The automatic visual inspection is important because it removes the subjective aspects and provides fast, quantitative and dimensional assessments. As PCBs normally contain complex and detailed patterns, manual visual inspection is very tiring and very subjective to errors. On the other hand, automatic systems do not get tired and are consistent. In electronics mass-production manufacturing, printed circuit board (PCB) inspection is a time consuming task. Manual inspection does not guarantee that PCB defects can be detected. The company whose turnover is not huge tends to do manual inspection because of high cost of optical inspection machine. In this paper we will design a system of low cost and of high accuracy which will benefit all.

There are various defects which a human cannot detect via a naked eye. In this paper an algorithm is designed using MATLAB which will automatically detect the defects in PCB. The main disadvantage of manual inspection of PCB defects are human errors, inconsistent grading and labor intensive. The inspection process can be automated by “PC-Based Machine Vision”. To identify the fatal defects the system uses a connectivity approach, it finds any type of error like: PCB board printing and missing holes, short circuit etc. For this research, the main defect focus is on PCB missing component, wrong hole size, etching, and various basic defects. This is very difficult to visualize by human eye. The result, obtained based on the proposed technique is possibly be applied in automated PCB manufacturing process.

II. LITERATURE SURVEY

Bare printed circuit board (PCB) is a PCB without any placement of electronic components (Hong et al., 1998) which is used along with other components to produce electrics goods. In order to reduce cost spending in manufacturing caused by the defected bare PCB, the bare PCB must be inspected. Moganti [2] et al. (1996) proposed three categories of PCB inspection algorithms: referential approaches, non-referential approaches, and hybrid approaches.

- Referential approaches consist of image comparison and model-based technique.
- Non-referential approaches or design rule verification methods are based on the verification of the general design rules that is essentially the verification of the widths of conductors and insulators.
- Hybrid approaches involve a combination both of the referential and the non-referential approaches.

Heriansyah et al. [R Heriansyah 2012] [3][4] proposed a technique that classifies the defects that could occur 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.

Shih-Chieh Lin et al [Shih-Chieh Lin and Chia-Hsin 2006] [5] proposed the method that can be divided into two stages, first stage was screening and the second stage was neural network to classify defect more accurately. 558 training samples were used to train the proposed system first. It was shown that pattern matching index is the optimal screen index in the first stage and in the second stage; it was shown that more than three indexes should be used to effectively identify defects.

Khalid et al. [N. K. Khalid 2008] proposed algorithm that can be implemented on bare PCB to identify and to group PCB defects. However, the major limitation of this algorithm is that the proposed algorithm is developed to work with binary images only, whereas the output from the cameras is in gray scale format. Although the conversion can be made from gray scale to binary format imperfection still can be occurred. Thus, this algorithm should be improved to handle the gray scale image format. Moganti et al.(1996) [2] Proposed the improved PCB inspection system in which an image registration operation is done to solve the alignment problem. A noise elimination procedure is designed in such a way that the resultant defects found in this algorithm is more précised compare to previous algorithm. Algorithm was effective to the image processing algorithm developed by Khalid by increasing the classification of 14 defects from 5 to 7 groups. Again the limitation of this algorithm is that it can work with binary images only.

Indera Putera et al [S. H. Indera Putera et al. 2012] did improvement to Khalid’s work by classifying seven groups. This is done by combining image processing algorithm and the segmentation algorithm. Each image is segmented into four patterns and then produced five new images for each pair of segmented reference and test images processed and thus 20 new images produced. Out of which, seven images were beneficial for defects classification.

The figure 1 shows the different type of defect present in the PCB.

![Fig. 1: Defects present in PCB](image)

Pin hole are the small gap that caused by the printed board outgassing during soldering. Pin hole formation during wave soldering is normally always associated with thickness of copper plating. Moisture in the board escapes through either thin copper plating or voids in the plating. Conductor breaking defect cause during the soldering process in which some of the portion is left due to which the circuit is not completed. Sometimes the component is missing which comes under this defect. Sometimes due to the negligence the conductor lines touch each other and the defect is called short circuit. Due to this defect there is high chance of damage when PCB is run. When two and more conductor matched with each other also comes under this defect.

III. SIMULATION

- **Image subtraction operation** The image subtraction operation is primarily used to reveal the differences between images. Subtracting one image from another effectively removes all objects that do not change while preserving those that do change in pixel value. The way the input images are processed is similar to the image difference operation. The difference between two images \( f(x, y) \) and \( h(x, y) \) is expressed as:

\[
\begin{align*}
    g_1(x, y) &= f(x, y) - h(x, y) \\
    g_2(x, y) &= h(x, y) - f(x, y)
\end{align*}
\]

Where \( g_1 \) and \( g_2 \) denote positive and negative images, respectively. These formulations compute the difference between all pairs of corresponding pixels from image \( f \) and \( h \).

- **Image difference operation** The image difference operation is performed to obtain a difference image of two images, specially the template image and the defective image. The method operates by comparing both images pixel by pixel using the XOR logical operator. This operation is similar to the image subtraction operation. The different between these two operations is positive and negative pixel image are combined together in an output image, and it is consider as a defective.
Image separation operation is used to compare the difference and similarity of objects between two input images and then separate the objects into two groups of output images. The first group of image output consists of objects that have difference pixels value and the second group of image output consists of objects that have similar pixels value.

Image addition operation is a method for combining objects in two images into one image by using the OR logical operator. In other words, this operation is used to create double exposures. If two images $f(x, y)$ and $h(x, y)$ are combined, the expression of this operation can be defined as follows:

$$g(x, y) = f(x, y) + h(x, y)$$

Flood-fill (filling hole) operator is a method for filling holes in an image. A hole can be defined as a background region that is surrounded by a connected border of foreground pixels. In this research, a flood fill operator which is formed from a combination of operations, namely dilation, complementation, and intersection operations have been employed for filling hole in an image.

Labeling operation is a procedure for assigning a unique label to each object in an image. There are a number of different approaches to labeling connected components. The approaches could be grouped as one pass, two pass, and multiple pass algorithms. Counted object comparator operation is used to compare the total counted objects when some objects are inserted into an image.

Image registration process is an important stage in inspecting real PCB images. Image registration or matching can be broadly defined as the process of finding a transformation that aligns one image to another. In this research, geometric transformation is used to find a transformation that aligns a template image and a defective image. The four geometric transformations used for the image registration process are rotation, scaling, skewing, and shifting.

The subtraction of images is one of the reference based inspection methods. This method is a powerful tool because it is simple, quick and effective in finding defects. Thus, this operation is used for defect detection in this study. However, this method suffers from inspection errors when noise occurs. This kind of noise can be introduced by the environment or the information transformation process used. Image subtraction can easily reduce the noise problem if the defective and template image can be aligned closely. By performing this method, two resultant images are produced: a positive and negative image. The positive image consists of open-circuit, pinhole, mousebite, and underetch positive defects. On the other hand, the negative image consists of missing hole, short-circuit and underetch negative defects.

A. BLOCK DIAGRAM OF THE DEFECT DETECTION ALGORITHM

![Diagram](image)

Fig. 2: Algorithm for Detection of defects

Fig. 3: Algorithm for Wrong hole size defect
IV. RESULT

The algorithm designed will detect the three defect Wrong hole size, Etching and the Short circuit defect. All the remaining defect will be detected later the defects is detected using the MATLAB in which all the steps of algorithm is implemented as shown in output. Using this algorithm we can reduced the time of inspection of PCB in the manufacturing industry. It is a very low cost and efficient with time and can made be available to everyone and can expand to other industry.

V. CONCLUSION

The algorithm designed will detect the three defect Wrong hole size, Etching and the Short circuit defect. All the remaining defect will be detected later the defects is detected using the MATLAB in which all the steps of algorithm is implemented as shown in output. Using this algorithm we can reduced the time of inspection of PCB in the manufacturing industry. It is a very low cost and efficient with time and can made be available to everyone and can expand to other industry.
VI. FUTURE WORK

In future the aim is to detect the all possible defects present in PCBs. The Labeling operation and Filtering will be used for the accuracy and efficiency. To find the various other method for the registration which will make sure the test image orientation and all parameter same as the reference image so that the subtraction of the image is good and output achieved is of high accuracy. In future the algorithm can be designed for the detection of the defect for multi-layer PCB which is not possible by using just camera and proposed algorithm. For that we need the optical inspection and different algorithm to detect the defect sin multi layered PCB.

REFERENCES