Preparation of Paper for the IEEE SSC 2006/ Dublin, Ireland Defect Detection and Classification of Printed Circuit Board Using Image processing in MATLAB

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***Abstract*— one of the major problem in the inspection of PCB is visual and quick inspection of faults it is really hard to find errors manually in a PCB the faults can be caused during the manufacturing process or by extreme exposure. In this paper we have used image processing as the primary tool for defect detection in a printed circuit board. By comparing faulty images with flawless PCB using matlab we have first detected 14 types of defects and then categorized them in four groups each group may have minimum of two defect and maximum of six defects. The algorithm works on a single layer PCB. The categorization of error helps in finding and eradicating the cause of error.**

I. INTRODUCTION

Image comparison method is the comparison of two images an Ideal PCB image and a faulty PCB image with errors. It consist of comparing two images pixel by pixel by XOR logic operator. One major requirement for such an arrangement is to have a proper platform to obtain an identical image for both the faulty and the flawless circuit then we can compare the image pixel by pixel. The main difficulty which we have to face in this technique is to find the best comparison between error free PCB image and with error PCB image.

More complicated Idea is feature and template matching but for such a method a large number of template are required. A Model based technique is one which consist of pre-defined models for example the graph matching methods which consist of structural and geometrical properties of image. The major complexity is pattern matching. Pattern attribute hyper graph makes the pattern matching technique more practical but still this method is very time consuming. DRC(Design rule checking) approach is used essentially to verify the width of the conductor and insulator .DRC checks to see if all the spaces and pattern are according to the standard and design rule. In this procedure an algorithm is applied directly to an image so it is relatively easy as compare to the other approach. This means it does not required any mechanical part or other complex part to get the image with errors. However this method has a drawback that it is very time consuming and great processing power is required to fulfill the human requirements of completing the task in time.

In Modern period according to the circumstances combined inspection approach is used .The hybrid method consist of the following two methods

- DRC Method
- Reference Comparison Method

It is formed in such a way to overcome the problems of both the methods Verification methods are generally limited to minimum conductor trace, angular error and spurious copper. At that point, PCB deformities which don't disregard the outline guidelines are recognized by Reference Comparison Methods. These routines can discover missing characteristics or extraneous characteristics. The outline guideline process locates all abandons inside little and medium characteristics while the examination routines are delicate to the biggest characteristics. Cross breed methodology makes utilization of both of these techniques as they complement one another and hence accomplish a full affectability of PCB location.

From the literary works survey, [4] it is discovered that just Wu and Heriansyah performed the imperfections grouping of the PCB. The different calculations focused just on PCB deformities discovery. In imperfection discovery, these kinds of deformities are not imperative. Then again, in deformities grouping, this sort of every deformity needs to be gotten. Firstly, Wu [wu et al, 1996] improved PCB imperfections order built in light of the pixel transforming operation. The system is separated into two stages: deformity discovery and imperfections grouping. Deformity location stage is fulfilled utilizing subtraction system until the second stage finishes using three records.

II. DEFECTS

A list of all the errors is given in Table 1. The faults that will certainly be harmful for the circuit for example Conductor breaking and short-circuit are dangerous faults. Imperfections are those errors which will cause the PCB to work incorrectly for example under etch, Pin hole, over etch and breakout.

During the drawing process two types of irregularities that can cause problem the overabundance of copper for example making the circuit short similarly the lack of copper might cause a short circuit or a missing conductor problem, excessive copper can cause projections or islands of copper or small gaps between two conductors. Extreme drawing can lead to pinhole, open circuit, gap, scratch (rodent chomp), and slim design.

Table I. Defect on a Bare PCB

Sr#	Error Type
1	Breakout
2	Pin-hole
3	Open Circuit
4	Under-etch
5	Mouse-bite
6	Missing Conductor
7	Spur
8	Short
9	Wrong Size Hole
10	Conductor Too Close
11	Spurious Copper
12	Excessive Short
13	Missing Hole
14	Over-etch

Figure I and Figure II show the illustrations of imperfection free PCB picture and damaged picture, individually. In spite of the fact that every imperfection indicated in the Figure II is an agent illustration of certain deformities, the shape also the measure of the deformities might shift from one event to an alternate Lately, the example width and space come to be more modest and more modest to increment the coordination rate of electrical segments for every unit range of PCB. Human eye cannot find such errors because these errors might be as small as 30 microns therefore a visual review frame work is required.

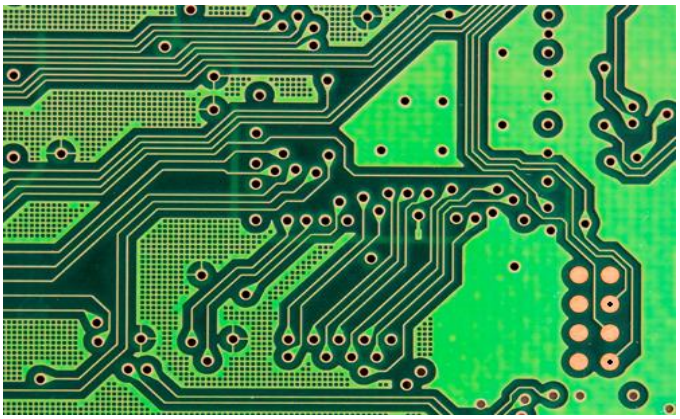
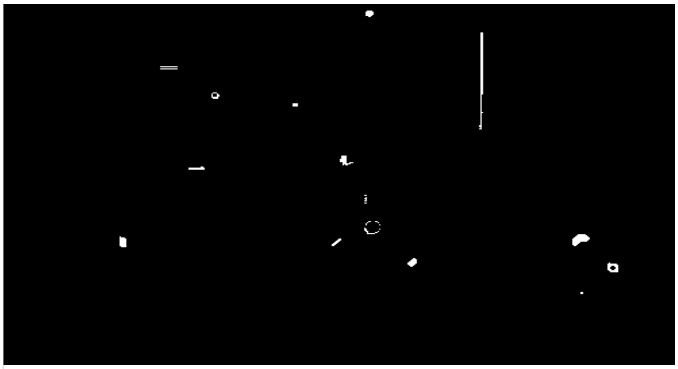


Fig I. Original PCB image



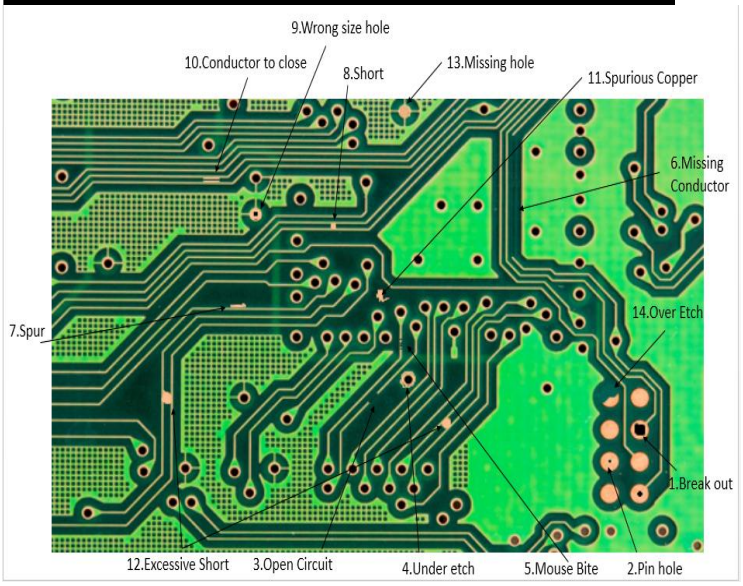


Fig II. Faulty PCB image

III. Methodologies

The image is first converted into a binary form as we know the PCB comes in different colors so it is necessary to choose the approximate value of threshold before converting the image in binary form. For example for this circuit we have found the best separation between the dark green, light green and golden color by keeping a threshold of .35.

The image distinction procedure, comprises of thinking about both pictures pixel-by-pixel by XOR rationale driver. The XOR operation works as an image examination operation so that all errors are visible. By using the XOR operation the difference between the faulty and the flawless circuit will return value of 1 and otherwise 0.Truth table of XOR is given in Table II and all faults are shown in Fig III.

Table II. XOR gate

Bit 1	Bit 2	Output
0	0	0
0	1	1
1	0	1
1	1	0

Fig IIIAll faults after XOR

A. NOT operation

The NOT operation is used to flip all the bits we have used not operation several times to extract the required error.

B. Imfill Operator

The Imfill operator is used to remove unwanted artifact from the image. This operator is used to fill all the holes in the PCB. The effect of Imfill operation is shown in Fig III. The Imfill operation takes 4 connected graph in 2 dimensional and 6 connected graph in 3 dimensional figure

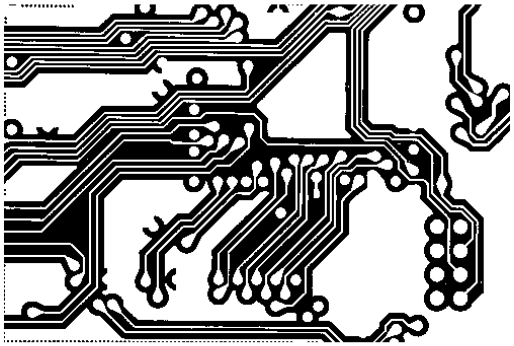


Fig III Image after Imfill operation

C. Addition and Subtraction Operator

Image subtraction help us get two type of images for this paper one is a positive image Template Image – Faulty image and the other is negative image that is Faulty image - Template Image. Both of the resultant images can be added up to get the result achieved by the XOR operation. Image addition is also used in this paper to regroup group of errors.

IV. ALGORITHM

A. Group I and Group 2

As explained by the block diagram defect free image is subtracted from defected image we get 8 of the defected errors. Imfill and Not operation are applied to this image and now the resultant image is subtracted from the 8 error image to make group 1 type errors image i.e. missing and wrong size hole as shown in Fig IV. The remaining 6 make group 2 i.e. Spur, Under etched negative, Short, Conductor to close, Spurious copper, Excessive short as shown in Fig V

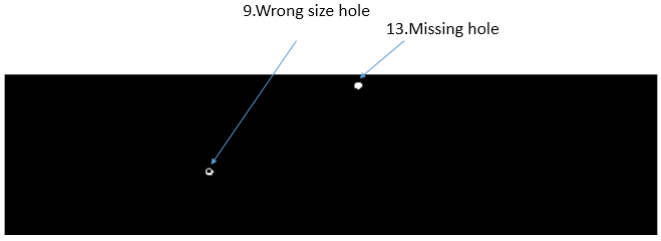


Fig IV

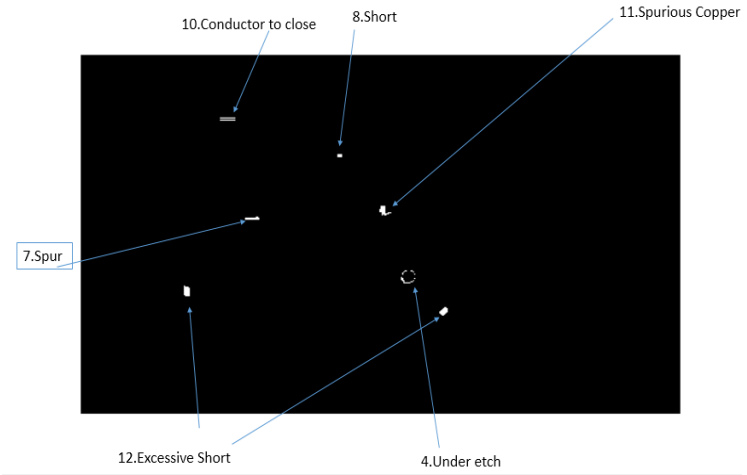


Fig V

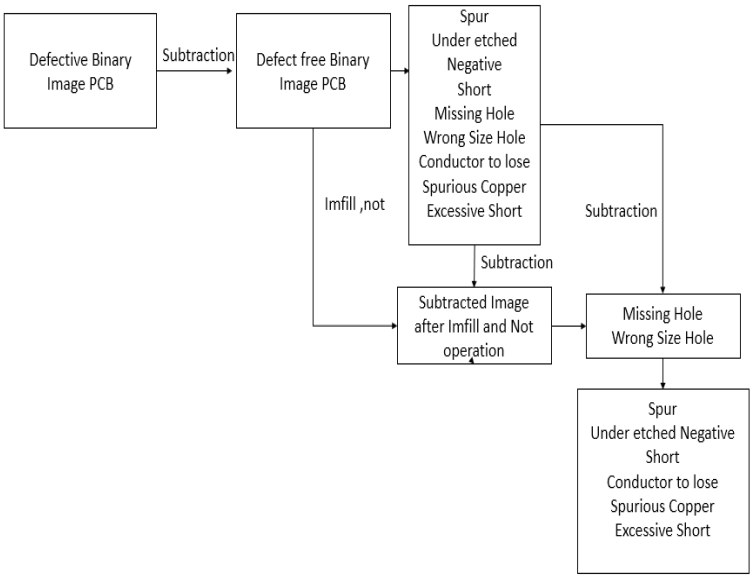


Fig VI

B. Group III and Group IV

Similarly for group III and IV as explained by the block diagram defected image is subtracted from defect free image we get 6 of the defected errors. Imfill and Not operation are applied to this image and now the resultant image is subtracted from the 6 error image to make group IV type errors image i.e. Breakout and Pinhole as shown in Fig VII. The remaining 4 make group III i.e. missing conductor, over etch, conductor to close. Mouse bite, as shown in Fig VIII.

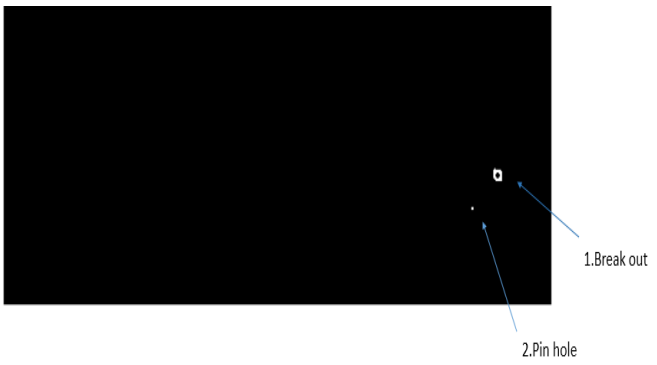


Fig VII

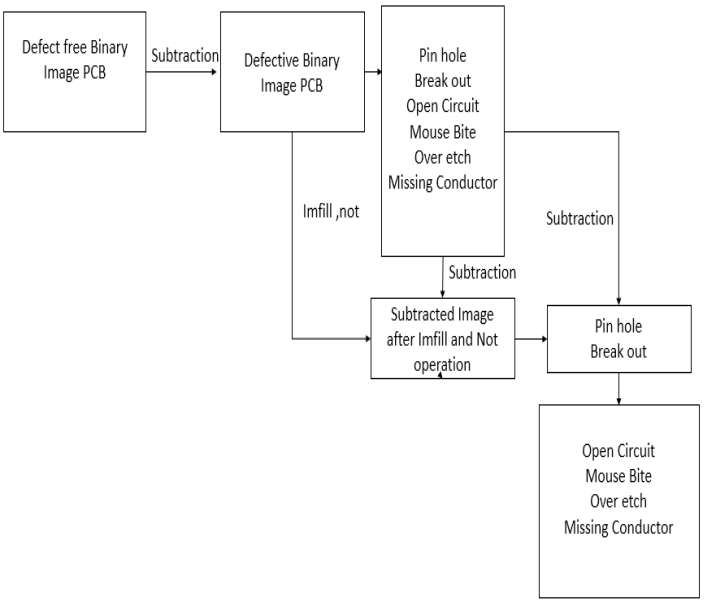


Fig IX

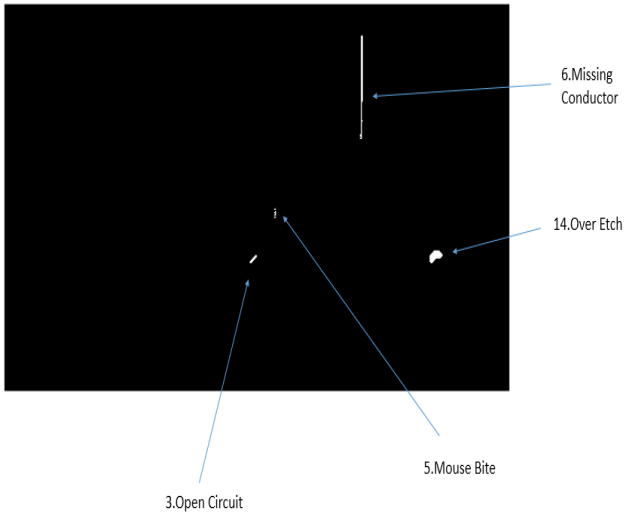


Fig VIII

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