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Detection of Printed Circuit Board Faults using Bottom-Hat Filter

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Abstract:
Printed circuit boards are designed in high density, small size and compact layout. It is obvious that faults like open hole, breakout and missing component may occur at the time of manufacturing. The electrical short circuit, dirt, corrosion also leads to problems like crack , burnt components in a PCB during usage. Identifying the faults in a non-contact method through image processing makes the work easy and safe. This paper proposes an algorithm of comparing reference PCB image with faulty boards image. Morphological operations Opening ,Closing, Bottom-hat filtering are applied on the images of test boards and finally subtracted from the reference image to locate the faults. This method identifies cracks, open hoe, missing components and short circuit faults in less time.

Keywords: *Morphological closing, Cracks, Fault detection, bottom-hat transform.*

I. INTRODUCTION

The Printed circuit board is the most vital element in any electronic equipment. Circuits are designed with electronic components and copper wire tracks for the conduction of electricity. The components are fixed in their appropriate positions where holes are drilled for it.The main consideration in placement of component is the orientation ,width,height of each component.

Circuit boards may be soldered with components in wrong position or misplaced components. Sometimesthe solder mask may be partially or completely absent between pads which leads to short circuit and less protection against corrosion. All these problems negatively affect the functionality and longevity of the circuit board. Circuit component failure is tracked by checking the signals passing through it.

Troubleshooting a PCB is quite often a challenge and tried with different approaches. Fault detection has been implemented with morphological thinning and thickening process [9] but the enhancement operations are restricted to noise filtering.Jithendra P R Nayak et al.[4] proposed a method of identifying faults before the etching process of a PCB.

The fault detection was carried out by converting RGbcolor space to YUV color space and Gaussian filter was used for smoothing.Canny operator was applied for detecting edges[2].Different types of cracks and image processing application on cracks was described by Sheerinsitara et al.[3].The method of finding thin hair cracks using morphological operations was shown by K.T.Talele et al.[8].

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The work carried out by S.H InderaPuteraet.al[7] shows a method of dividing PCB images into four different segments of well-defined generic patterns and later fed into the image processing morphological operations to defect the faults and classifying it to different categories.The thermal image of printed circuit board is taken for analysis and algorithm is developed by Ms.Chaitali R. Wagh [6]. The analysis done by ArunMohan,SumathiPoobal [1] describes the various methods implemented so far to identify the cracks.

The proposed algorithm is based on morphological dilation,erosion, closing and bottom-hat filtering operations .It is effective and straightforward method for identifying various faults in printed circuit boards.

II. MATHEMATICAL MORPHOLOGY

Mathematical Morphologyis a nonlinear sub-part of the sign handling field which manages the use of set hypothesis ideas to the area of image investigation.. Morphological administrators are nonlinear changes, which alter geometric properties of pictures .Itcan be utilized to process and investigate the images. Morphology gives an elective way to deal with computerized picture handling dependent on the idea of shape originated from set hypothesis, and not on traditional numerical displaying and examination.

Morphology is a branch of image processing which has been successfully used to provide tools for representing, describing, and analyzing shapes in images.The extraction of geometrical and topological information from an unknown image through transformations using another, well-defined set known as structuring element (SE).All morphological operations are performed on binary images.

a)Structuring Element:

It is the two dimensional matrix consisting of zeros and ones much smaller than the image being processed. Data of the unique set structure and the change is acknowledged by exceptional structuring component. Along these lines, the outcome is correlative to certain qualities of structuring element. The centre pixel of structuring element is the origin. It can be of any shape like disk,square,diamond or randomly defined structure.

b) Dilation& Erosion:

Dilation is used for expanding an element A by using structuring element B.Erosion is a change of contracting, which diminishes the gray scale estimation of the picture, while dilation is a change of growing, which builds the gray scale estimation of the image. In any case, these two are delicate to the picture edge whose intensity changes clearly. Erosionchannels the internal picture while dilation channels the external image. Dilation is the greatest pixels set association when organizing component supersedes picture, while erosion is the base pixels set association when image is covered by structuring element.

The dilation of A by B and is defined by the following equation:

$$A \oplus B = \{z|(\hat{B})z \cap A \neq \emptyset\}$$

This equation is based 0n obtaining the reflection 0f Babout its origin and shifting this reflection by z.The dilation of A by B is the set of all displacements z, such thatand A overlap by at least one element. Based on this interpretation the equation of can berewritten as:

$$A \oplus B = \{z|[(\hat{B})z \cap A] \subset A\}$$

In dilation and erosion the input image is probed using structuring element B.

Erosion is usedfor shrinking of element A by using element BErosion for Sets A and B in Z2, is defined by the following equation:

$$A \ominus B = \{z|[(B)z \subseteq A\}$$

This equation indicates that the erosion of A by B is the set of all points z such that B, translated by z, is combined in A.

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c)Opening & Closing :

Opening is erosion followed by dilation and closing is expansion followedbyerosion. Opening by and large smoothes the shape of a picture, breaks limited holes. Rather than opening, closing will in generaltakes out little gaps, and fills holes in the shapes. In this manner, morphological activity is utilized to recognize image edge, and in the meantime, denoise the picture. Among every single morphological administrator, the opening and shutting operations are key.

Opening is the operationerosionofA by B, and then dilate the result by B. In other words, opening is the unification of all B objects entirely contained in A.

Closing is the operation of dilation ofA by B, and then erode the result by B . It is the group of points, which the intersection of object B around them with object Awhichis not empty.

d)XOR operation:

Logical exclusive OR operation between A and B produces difference between two imagesThe XOR operation will demonstrate to us the deformity in examined image contrasted and reference image[5].

e)Hat-transforms:

Morphological operators remove structure from images. The hat-transforms is used for detailed extraction of structure .The top-hat transform is defined as the difference between the original image and its opening. The opening of an image is the collection of foreground parts of an image that fit a particular structuring element. The bottom-hat transform is defined as the difference between the closing of the original image and the original image.

In Morphology of computerised image processing ,top hat transform is a process that removes small components and details from the image.The white top hat is the difference between actual image and opened image by a structuring element whereas dark top hat transform is the difference of closed image and actual image. Top hat transform is useful in image enhancement and feature extraction.

Bottom-hat operator subtracts image from result of morphological closing on the input image. This allows getting all object parts, which were added by closing filter, but not removed after that due to formed connections.

The PCB for testing is captured with a camera and the image is analysed with different image processing operations in MATLAB in order to identify the fault.

A reference image of Original PCB is taken for comparing in the testing operation.

- Both reference and testing PCB are in RGB color images. As color involves complexity of analysing the image in three planes, it is converted into Gray image.
- The gray images further thresholded to form binary image which is suitable for morphological operations.
- The test PCB is processed with dilation followed by erosion operation. It is equivalent to closing operation.
- The operation XOR betweentestPCb and reference PCB identifies minor crack or track joint faults .
- The bottom hat transform operation is performed by subtracting the closed image from the reference PCB binary image. The residualimage shows the faults like missing component,missing holes ,Undesired holes ,any component burnt due to overheat ,melting of copper track etc. in test PCB .

III. PROPOSED ALGORITHM

The following figure 1.describes the block model of the proposed algorithm.It is implemented in MATLAB image processing tools and tested for different test PCB's

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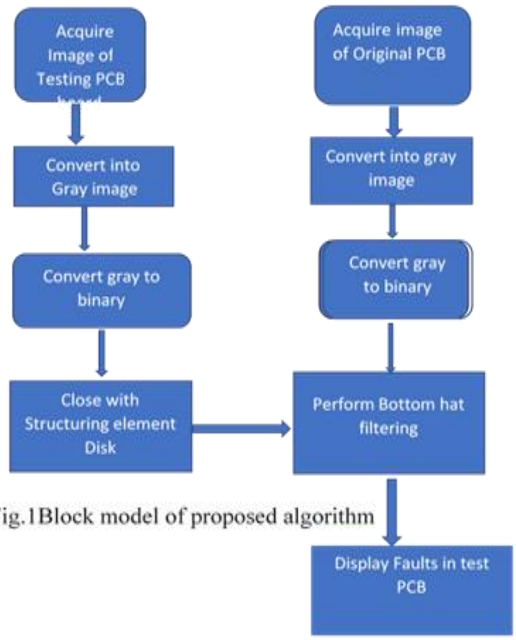

Fig.1Block model of proposed algorithm

IV. RESULTS

Based on the testing implemented in MATLAB7.0 version.The input reference PCB is a RGB image as shown in fig 2(a).It is converted to gray the thresholding applied to get binary image as shown in fig 2(c) image is shown in fig2.b.Similarly the PCB board with fault taken for testing in color format is given in fig2 (b) and its binary image in fig 2(d).the morphological closing of faulty board is shown in fig 2(e). The final result of faults identified is displayed in fig 2(f). The second set of images are shown in fig 3.(a-f) for another faulty board taken for testing.

Sl. No	Image name	Type of fault	Time taken to identify fault
1	Cracktest2.jpg	Thin crack, missing hole	0.6790 sec
2	Secfault2.jpg	Missing component, burnt point	0.8090 sec
3	Board1faulty.jpg	Line break, missing hole	0.7980 sec
4.	Cracktest.jpg	Multiple cracks	0.609 sec

Table1: Time taken for fault identification

The testing conducted on different PCB boards and time taken for identifying the faults is shown in table1. It is clear that this method is taking very less time of an average 0.74 sec in identifying fault compared to the algorithm done by Samriddhikakadietal.[9] where the time elapsed is 17.95sec.

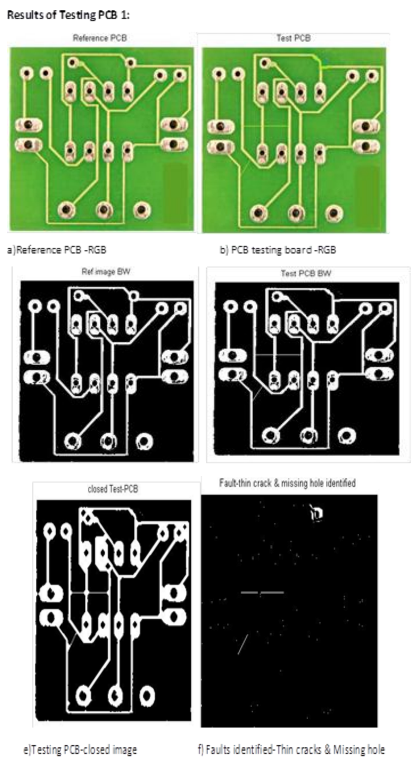

Fig 2. Results of testedPCB board

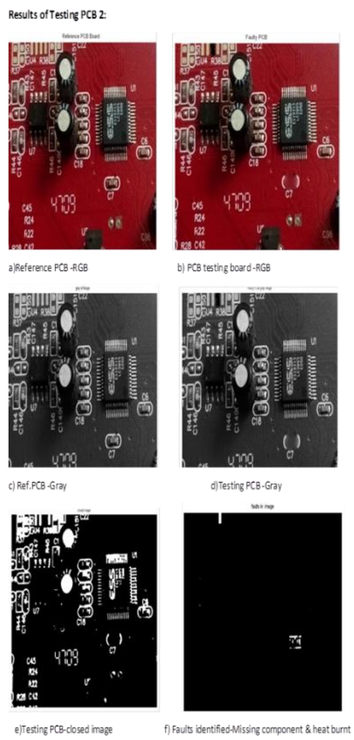

Fig 3. Results of testedPCB board-2

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V. CONCLUSION

This paper presents a method of identifying faults through Image processing. From the experimental results, it is observable that minor cracks and holes are locatable with different structuring element.The selection of shape and size of structuring element is vital in getting accurate results. Faults thin crack, missing holes, missing tracks, joint in track, missing component, burnt component, copper melted points are identified in the tests conducted. The faults are identified in less time average around 0.74 sec.The same algorithm can be applied to identify cracks in bone structure, fabric damage and oil pipeline leakages due to minor holes or cracks.

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