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Computer Vision System for Automatic PCB Inspection & Quality Analysis with Auto Rejection

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***Abstract*— In this paper, we present a Computer Vision system for printed circuit board (PCB) automated inspection. In the last years, PCB industry has been invested in manufacturing automation improvement. This is known, especially in measurement and inspection field. We can note that the tolerances on PCB assembly become more accurate. With computer hardware and cameras advances, new Computer Vision algorithms should be developed, and applied in industry with low cost. Besides, new visual inspection systems using computers should be implemented to solve smaller tolerance requirements.**

***Keywords* — Computer Vision algorithms, PCB.**

I. Introduction

This Visual inspection processes automation has become essential to improve quality in printed circuit board (PCB) manufacture. Industry requires automated inspection since, in the manufacturing processes, there are uncertainties, tolerances, defects, relative position and orientation errors, which can be analyzed by vision sensing and computer algorithms. Hence, Computer Vision measurement techniques present regularity, accuracy and repeatability in noncontact measurements and inspections. Those systems differ to the subjectivity, fatigue, slowness and high cost associated to human inspection (Leta *et al*., 2005). During the last years, in PCB industry there were many factors that encouraged automation. The most important one consists of the technological advances in PCB's design and manufacture. This occurs because of the fast board functionality innovations. New electronic technologies need new PCB designs, with smaller dimensions, new components and new functionalities. This tendency is generate new challenges and principally it is causing some difficulties to human visual inspection. The necessity of reduce the spent time to produce a PCB is another important reason that forces the automation.

We are interesting in developing a computer vision inspection algorithm applied to bare printed circuit boards, i.e. boards without components. In the literature, we can find a large number of PCB inspection techniques applied to bare PCB. Generally, there are three main approaches: referential, non-referential and hybrid. The referential techniques perform a PCB comparison with a standard image, stored in an image database. Any pertinent difference between the model and the inspected board is reported. The non-referential methods verify the board based on the design specification data. In this case, each printed board is analyzed, according to the available artwork data. And finally, the hybrid systems use referential and non-referential techniques to analyze PCB.

A. PCB Defects

The PCB defects are normally grouped in two categories, the fatal defects and potential defects. The system identifies the potential defects using an image comparison technique, subtracting the reference board image from the tested board image. To identify the fatal defects the system uses a connectivity approach, it finds any type of error like: scratches, breaks, bridges, under etching or over etching, which blocks the passage of electricity or make a short circuit. The results, obtained by the developed approach, are possible to be applied in automated industrial systems with some improvements.

a) All operations are GUI based.

b) Since Input image can come through Noisy source so w are removing the Noise and enhancing the contrast of received image.

c) Using Image Subtraction method we are finding the errors.

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d) Using labeling of components we are finding the faults in red rectangular box with its coordinates.

e) Using XOR operation, we are getting the perfect PCB image from the damaged PCB

Overall we can say that our research provides the best way to find the faults in the PCB, their types and make the defected PCB a perfect one. There are 5 main components of this PCB fault detection research

a) To Read the PCB that is to be tested.

b) Enhance the Image.

c) Read template Image.

d) Defect detection.

e) Defect correction.

The remainder of this paper is organized as: PCB default detection work till now in section II. Design principles and a hardware implementation for PCB fault detection algorithm is described in section III. In Section IV we will describe Bare PCB Defects and the reasons for the defects in the PCB. In section V we will describe our research contribution and flow of work. We conclude with a discussion on future work in Section VI describes future scope and our research conclusion.

II. RELATED WORK

In the past years many methods have been carried out till now for the detection of faults in the PCB. Initially the faults have been detected manually using magnifying system but this was not perfect system because manually it's very tough to find the errors or faults which are present in the PCB. Since the faults are very minute and tough to find so latter on image processing systems are get in used. In this system image of the PCB which is to be tested is taken and compared with the perfect PCB. If any fault is there then the faults are easily detected. Main advantage of this system is that it easily finds out all the defects within a short span of time. Other thing with this system is it also locates the exact location where the fault is present and also shows the type of defect; with the help of this we can take immediate action for the correction of the PCB. Our system is somehow similar to this system where faults can be found out and the correct PCB image is also shown with no faults.

III. HARDWARE IMPLEMENTATION

We now discuss the design principles of the system that we are going to use for finding the faults in the PCB. we will also see the principles of our system.
Basically our system is GUI based so there is very less or we can say that no use of the hardware but instead as a hardware material here we are only using the PCB.

(a) PCB:

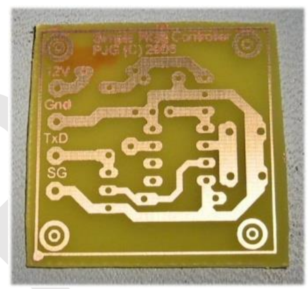

Figure 1: Printed Circuit board

PCB mainly means printed circuit board which is a mechanically supported and electrically connects the electronic components using conductive tracks

(b) REJECTER SYSTEMS

An extensive product line-up of rejecters has improved safety and validation, as well as improved speed (up to 2.1 times faster than conventional Anritsu products). The reject systems operate at the speed of 250 products/min. The standardization of functions on the rejecter ensures reliability and safety, including rejection confirmation, Rejection operation check and detachment check.

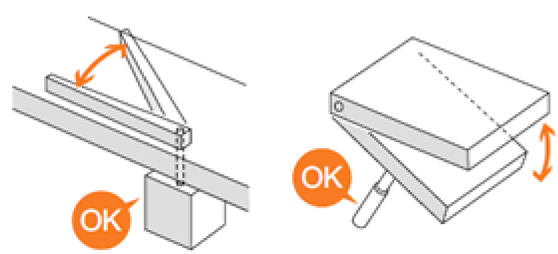

Figure 2: Common PCB rejecter

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In the figure 2, common PCB rejecter system is shown, PCB rejecter system ease our process for checking the defected PCB, it will directly rejects those PCB which are having some defects and not suitable for the system. Although there are several type of PCB rejecter present for checking the PCB such as Flipper type, Dropout type, Up and out type, Air Jet type, Trip type, pusher type, Turning type, carrier type, chute type and shuttle type.

IV. DEFECTS AND CAUSE OF DEFECTS

In a defected PCB there are various types of defects and these defects can be categorized into following types:

1. Breakout
2. Pin hole
3. Open
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

All the above defects can be easily seen easily in the below figure 3 with specified serial number.

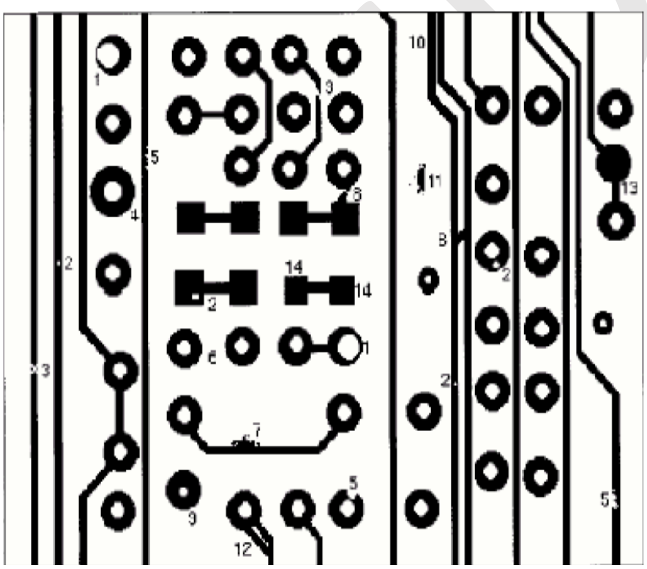

Figure-3: Various types of PCB faults

V. CAUSE OF DEFECTS

There are some defects commonly found on PCB. Conductor breaking and short-circuit are characterized as fatal defects. Pinhole, breakout, Over etch, and under etch are characterized as potential defects. Fatal defects are those in which the PCB does not attend the objective they are designed for and potential defects are those compromising the PCB during their utilization. During etching process, the anomalies occurring on bare PCB could be largely classified in two categories: the one is excess of Copper and the other one is missing copper. The incomplete etching process leaves unwanted conductive materials and forms defects like short, extra hole, protrusion, island, and small space. The excessive etching makes open, pin hole, nick (mouse bite), and thin pattern. In addition to the defects mentioned above, some other defects may exist on bare PCB, for example, missing holes (due to tool break), scratch (due to handling mistake), and Cracks.

VI. PCB INSPECTION METHOD

Basically PCB inspection method is categorised into two main parts first is Referential and the second is Non-referential, further these two methods are also classified in different parts.

1) Reference based Inspection: This consists of mainly two processes. The first step is the coarse alignment between the detected patterns and the design patterns. The second step is the defect detection named “Local Pattern Comparison” method in which small defects up to 1.5 pixel-size can be detected without being influenced by pattern registration errors and sampling errors. The defects are detected by structure character, in which is not directly doing image subtraction operation.

2) Non-Referential inspection: This PCB fault detection technique can detect error in the PCB without considering a reference board. The research succeeded in verifying vertically, horizontally and 45 degrees oriented traces. The method is based on connected component analysis, which is a natural way to extract the connectivity information of the conductors of a

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PCB. The registration of the PCB holes, which is a common problem related to referential model techniques, is solved by the concept of zone of influence of each hole.

3) Hybrid Inspection: A system developed in this research can handle all of the defects simultaneously with the same approach and is significantly faster compared to the existing approaches. The system consists of three major phases: the first step is the segmentation of the golden PCB image into basic sub-patterns, the second step is the learning phase, and the third and final step is the verification/inspection phase. The system introduced the application of neural networks and fuzzy logic to PCB inspection. The method is highly parallel and works at the sub-pattern level. This study chooses image comparison techniques to be the principal inspection method for searching PCB defects. Then we use edge detect and edge-tracing process to define types of defects. Image subtraction is the simplest and most direct approach to the PCB inspection problem.

VII. OUR WORK FLOW

In this section we will see the flow of work with the help of a flow diagram which shows how the process goes on. At first the selection of PCB image is done which is to be tested, and then the image will get buffered to arrange its correct pixels, then selection of template image which is compared with the defected image. Then XOR operation is applied with the image which is used to compare the template image with the PCB image. After this we will get the resultant image, means that image is error free and then the last steps followed with the thresholding and then practical analysis is done.

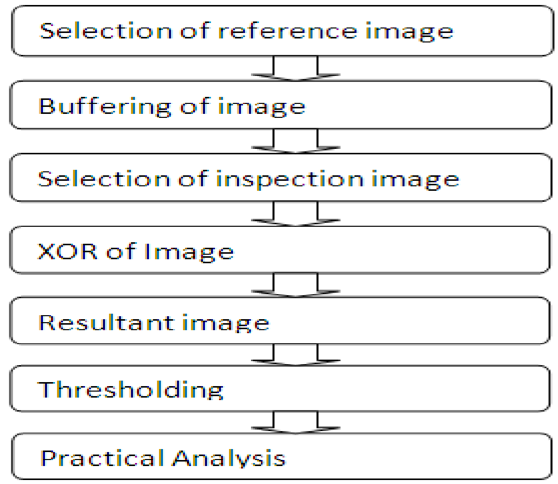

Figure-4: work flow of the system

VIII. RESULT AND DISCUSION

For the detection of error in the PCB we are just providing the set of instructions which acts as a GUI and it will automatically performs all operations if once it's executed. Some of the basic operations that will be done when we execute the program are as follows:

(1.) Read Test PCB
(2.) Enhance Image
(3.) Read Template Image
(4.) Defect Detection
(5.) Defect correction

Below mentioned figures shows the complete process which is mentioned above:

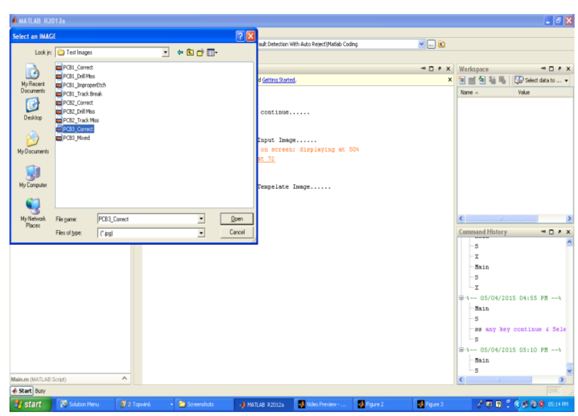

Figure5: Selection of the PCB image to be tested

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In figure-5 we can see the UI which is completely based on the MATLAB software, through which we are selecting the image which is to be tested.

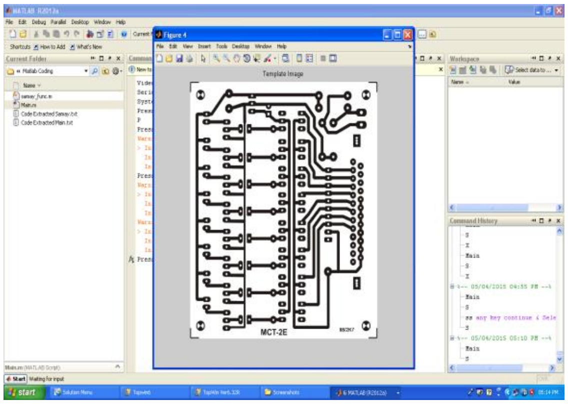

Figure 6: Selection of the template image

Above figure 6 shows the selection of the template image which is used to compare with the image which is used to be tested. After comparing only with the template image errors can be detected in this system.

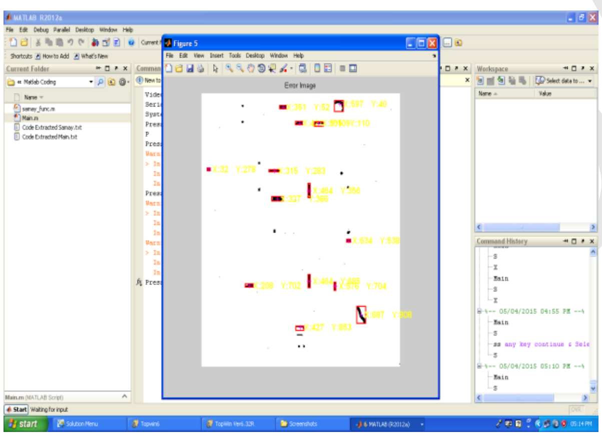

Figure 7: Errors found in the PCB

After comparison in between the image which is to be tested and the template image, errors automatically found in the tested image of the PCB with its coordinates. The errors can be easily seen in the red color or in the white color.

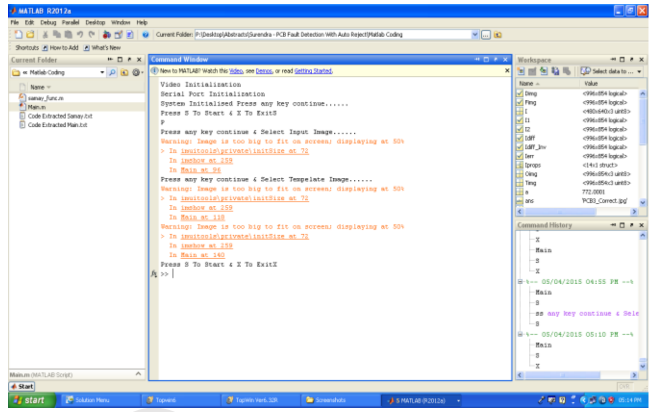

Figure 8: Command window

Command line is shown in the above figure 8, from which each and every instruction is given and the errors in the PCB will be detected from here.

IX. CONCLUSION AND FUTURE WORK

A Computer Vision system for printed circuit board (PCB) automated inspection was developed to detect bare-board manufacturing errors, like missing tracks, circuit shorts, missing holes, opens, breaks, etc. The system uses standard PCB images; their characteristics are saved in a database. The adopted referential approach compares PCB images to the standard images. Some difficulties were observed. One of them consists in the pre-processing technique. It is important that the environment lighting should be uniform and that all inspected PCB belong to the same category. It permits to choose a satisfactory segmentation technique, which can be applied to all PCB images. In the other hand, if it doesn't happen, it will be necessary to calibrate the system every time we change the reference PCB or environment illumination attempting to detect PCB fails, we propose a new methodology that reduces the computer complexity of scanning the whole board. We considered the PCB separated in small images. It is possible after the system identified the regions that contain fatal errors. A connection analysis method is applied to each small image.

The obtained results confirm that the methodology is feasible however; some new improvements should be done in other to convert the system in an industrial real time system. For instance, we can use parallel processing to test

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each small image detached. This should improve efficiency and reduce computational time. Future works consists in revising the methods used to analyze PCB with components. In this case it should be detected components absence and replacement, misaligned components, etc.

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REFERENCES

[1] Sonal Kaushik & Javed Ashraf, "Automatic pcb defect detection using Image subtraction method" October 2012.

[2] Ruzinoor Che Mat, Shahrul Azmi, Ruslizam Daud, Abdul Nasir Zulkifli & Farzana Kabir Ahmad, *Fakulti of Technology Management, Universiti Utara Malaysia, 06010 Sintok, Kedah Darulaman. Malaysia.* "Morphological Operation On Printed Circuit Board (PCB) Reverse Engineering Using MATLAB**".**

[3] Madhav Moganti, Ficret Erkal & Cihal H. Dagli, University of Mussouri, Rolla Rolla,MO 65401, "Automatic PCB Inspecttion Algothrithm: A survey".

[4] Jagadish.S.Jakati1 & Sidramayya S Matad, Belagavi, Visweswaraiah Technological University, India, "PCB defect detection based on pattern matching and segmentation algorithm", *IJARCCE, Vol. 3, Issue 9, September 2014.*

[5] Prachi P. Londe and S. A. Chavan, EXTC Dept, DBNCOET Yavatmal, India "Automatic PCB Defects Detection and Classification using Matlab", June 2014.

[6] Malge P.S. & Nadaf R.S.,Department of Electronics, Walchand Institute of Technology, Solapur, 413006 "PCB Defect Detection, Classification and Localization using Mathematical Morphology and Image Processing Tools" , *International Journal of Computer Applications (0975 – 8887) Volume 87 – No.9, February 2014.*

[7] Fabiana R. Leta, Flávio F. Feliciano & Flavius P. R. Martins, "COMPUTER VISION SYSTEM FOR PRINTED CIRCUIT BOARD INSPECTION" ABCM Symposium Series in Mechatronics - Vol. 3 - pp.623-632 Copyright © 2008.

[8] Noor Khafifah Khalid, Zuwairie Ibrahim, And Mohamad Shukri Zainal Abidin, *Universiti Teknologi Malaysia,* IJSSST, Vol. 9, No. 2, May 2008, "An Algorithm To Group Defects On Printed Circuit Board For Automated Visual Inspection".