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AUTOMATIC PCB DEFECT DETECTION USING IMAGE PROCESSING ON EMBEDDED PLATFORM

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Abstract - *Printed Circuit Board is the heart of the electronic automation system because PCB are the most common method of assembling electronic circuits. PCBs are categorized into two types, i.e., bare PCB and the assembled PCB which is commonly known as PCBA. During the manufacturing of PCB, many defects are introduced which are harmful to accurate circuit performance. A PCB Defect detection system uses optical vision which is used to find faults occurred in manual inspection and gives fast, quantitative and dimensional quality. There are many algorithms that have been developed for PCB defect detection, using contact methods or noncontact methods. In Contact method, the connectivity of the electronic circuit is being tested but it is unable to detect major cosmetic defects. Non-contact methods include selection from x-ray imaging, ultrasonic imaging, thermal imaging and optical inspection using image processing. There are three categories of PCB inspection algorithms that's, referential approaches, non-referential approaches, and hybrid approaches. In referential approach, a standard PCB image has to be compared with a PCB image which has to be inspected, and by using a simple subtraction algorithm we can detect the defected regions in the PCB. My focus for this, is to detect defects on printed circuit boards. The results obtained from this method shows that this method can effectively detect common defects on the circuit board, consuming less time than the other practices which makes this system cost effective, fast processing, very accurate and an efficient method to detect the defects.*

***Key Words*: Image Registration, Transformation, Feature detection, Feature Matching**

1. INTRODUCTION

A Printed Circuit Board (PCB) is used everywhere from a small toy to a big electronic equipment/machine, which we used in our daily life. PCB consists of an electronic circuit with various electronic components mounted on its surface. During the manufacturing of PCB many defects are introduced which are harmful to accurate circuit performance of that product.

There are two groups in which PCB defects can be categories:

- Functional defects - Functional defects are related to its circuit operation and it can seriously affect the performance of the PCB by causing it to fail.
- Cosmetic defects - Cosmetic defects affect the appearance of the PCB, but it can also threaten its performance in the long run because of the abnormal heat dissipation and distribution of current in the electronic equipment.

A PCB without any placement of electronic components is called Bared PCB . Bare PCB consists of meta coating, patterns, and conductive pathways. The bare PCB must be inspected, in order to reduce cost spending in manufacturing caused by the defected bare PCB. Moganti et al. (1996) proposed three categories of PCB inspection algorithms[22]: (i) Referential approaches consist of image comparison and model-based technique. (ii) Non-referential approaches are based on the verification of the general design rules that is essentially the verification of the widths of conductors and insulators, there is no reference image in this method. Lastly, (iii) hybrid approaches involve a combination of the referential and the non-referential approaches.

These PCB inspection approaches are mainly concentrated on defect detection and to reduce manufacturing costs and time associated with defected bare PCBs. The inspection of bare PCBs is required as the important step of the manufacturing process. However, defect detection did not provide satisfactory information for repairing and quality control work, since the type of detected defects cannot be clearly identified. Based on this incapability of defect detection, defect classification operation is needed in PCB inspection. Therefore, an accurate defect classification procedure is necessary for an

automatic inspection system during PCB production process.

There are 14 types of defects for single layer, bare PCBs[23], and those defects are listed below:

No.	Defect name
1	Breakout
2	Pin hole
3	Open circuit
4	Under etch
5	Mouse-bite
6	Missing conductor
7	Short circuit
8	Wrong size hole
9	Conductor too close
10	Spurious copper
11	Excessive short
12	Missing hole
13	Over etch
14	Spur

2. PROPOSED ALGORITHM

2.1 Image Acquisition:

This step means acquiring the image that is to be tested for defects which could be of various image formats such as bitmap (.bmp), portable network graphics (.png), JPEG (.jpg), etc. We can take the same image format or different image format for another image i.e, Reference image of a defect free PCB is taken as input.

2.2 Image Registration:

The reference and test image have different orientation and size, hence images are registered before the image operations. The pixels of both images are mapped accordingly to their similarity of features in the image. For a rotated image the angle of rotation is calculated and after calculating the angle of rotation, the image is then re-rotated and resized for registration.

2.3 Image Complement:

For subtraction and defect detection the image of the PCB which is to be tested is to be complemented. With the help of converting the image to Gray scale and then complementing, the complement of a 3D RGB image has to be done. In Image complement each pixel value of the image is subtracted from the highest value of the image i.e., if it is an 8-bit image maximum value is 28-1 which is equal to 255.

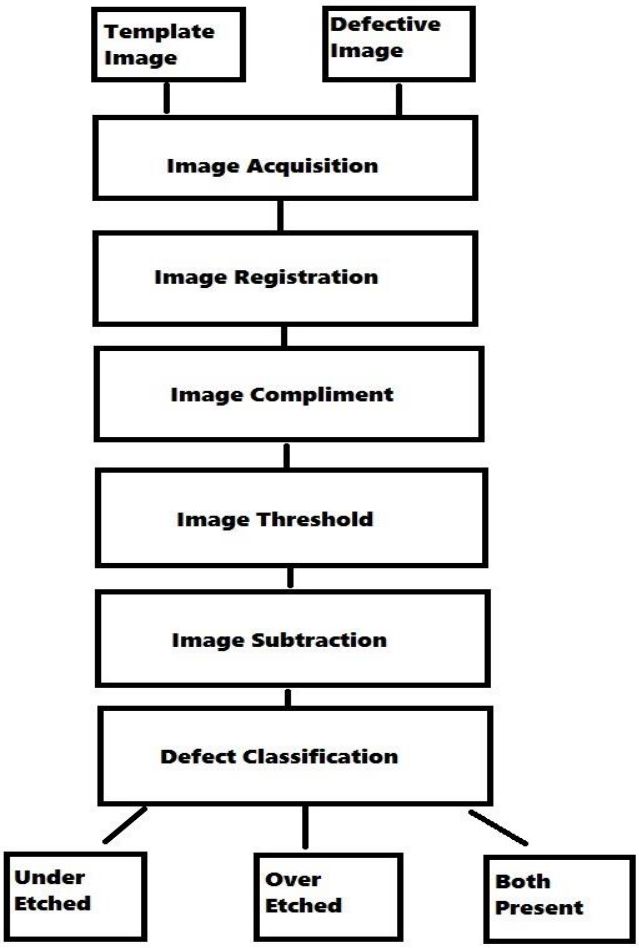

Fig -1: Block Diagram of proposed Algorithm

2.4 Image Threshold:

After that the Defects in the images are Threshold according to their size and shape. Image threshold is used to make the pixel below a Threshold value zero i.e., black and pixel having value above the threshold value one i.e., white. By using this operation, it is easier for the appearance of PCB tracks, which is now more visible in an image. The image which is to be tested and the reference image are given same threshold value to reduce complexity of the program.

2.5 Image Subtraction:

After Image threshold, the next step is image subtraction i.e., subtraction of defective/test image from the reference image. The subtraction is done pixel by pixel of the reference image and the test image. The Image registration provides an easy access for image subtraction as a matrix operation.

2.6 Pixel Manipulation:

The defects are seen as white spots in the resultant image, which is caused by image subtraction operation that is performed previously. If no spots exist in the image, it means that the PCB has no defect. If any spots exist in the resultant image, then defects exists in the image.

3. METHODOLOGY

I have used image registration method here. The registration is explained to take place in four basic models which are described as follows:

1. Feature detection:

   Salient and distinctive objects (closed-boundary regions, edges, contours, line intersections, corners, etc.) are manually or, preferably, automatically detected. For further processing, these features can be represented by their point representatives (centers of gravity, line endings, distinctive points), which are called control points (CPs) in the literature.

2. Feature matching:

   In this step, the correspondence between the features detected in the sensed image and those detected in the reference image is established. Various feature descriptors and similarity measures along with spatial relationships among the features are used for that purpose.

3. Transform model estimation:

   The type and parameters of the so-called mapping functions, aligning the sensed image with the reference image, are estimated. The parameters of the mapping functions are computed by means of the established feature correspondence.

4. Image resampling and transformation:

   The sensed image is transformed by means of the mapping functions. Image values in non-integer coordinates are computed by the appropriate interpolation technique.

4. EXPERIMENT AND RESULTS

The Algorithms contain different Image Operations each Image Operation gives out a result. The following chapter focuses on results of the operations done on each part of the project and the final result obtained from these operations.

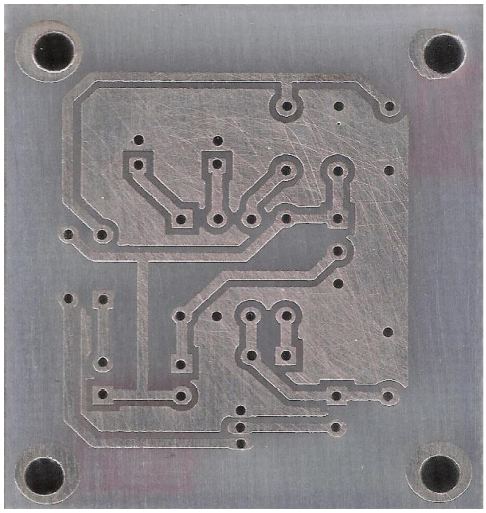

Fig -2: Desired Image

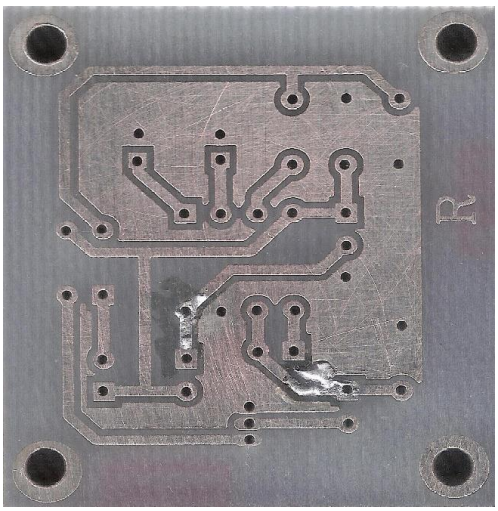

Fig -3: Input Image

Figure- 2 and 3 is the desired image and the input image, which I have used for the implementation part of this project.

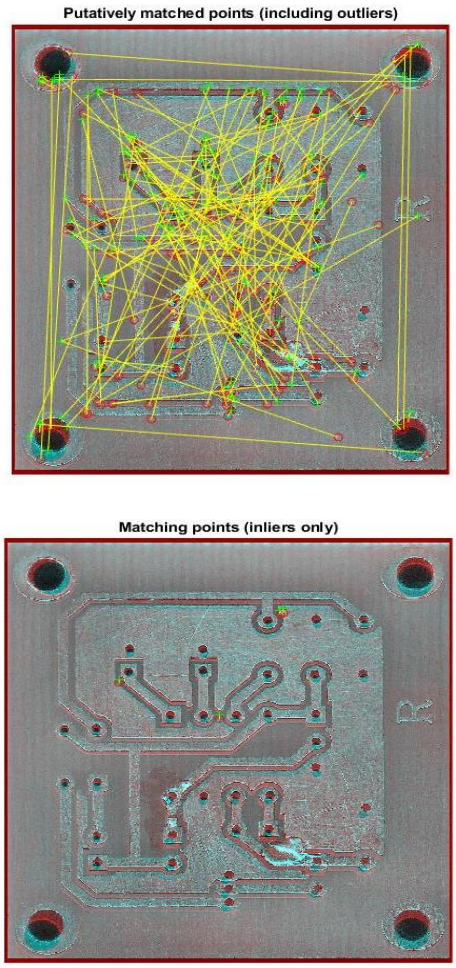

Fig -4: Matched points inliers and outliers

In Figure 4 The image shows matched points which are used for registration in case of rotated images. The template image is rotated so the points are matched and the angle is recovered which gives us aligned images which help in further operations.

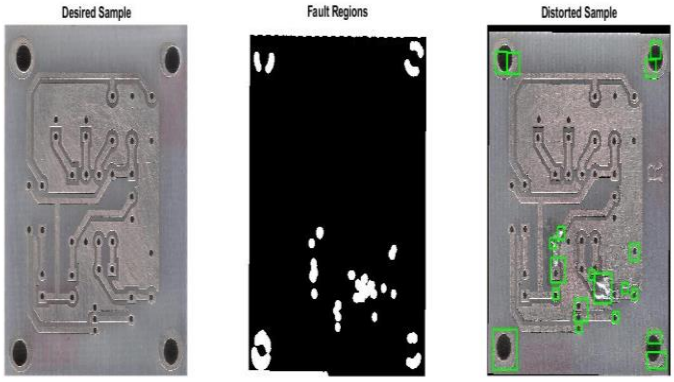

Fig -5: Output of proposed method

The above image is result of image subtraction of the template and defective PCB Image. Second image shows the white spots on the Image depict that some defect is present in the Image short, spur and under-etch. And in third image it is converted back to RGB and the boxes have been drawn to have a clear idea of faults in the PCB .

5. CONCLUSION

Printed Circuit Boards are being used everywhere so, it is very important and essential to examine Printed Circuit Boards. Using Image processing techniques and algorithms, examination process has become fast, reliable and effective compared to manual process because it excludes labor intensive job. Automatic PCB defect detection method makes it more advantageous than the manual one. I have presented my implementation of a technique to Detect PCB errors. My technique shows that it is feasible to use the software and detect the errors present in PCB so that further malfunction can be avoided. Its main objective is to detect the errors that are present in PCB during Mass Production. This proposed method can also be used in college labs to detect the errors in PCB which engineering students have to make for their courses. I believe that PCB making or production can be increased efficiently and error rates can be reduced significantly by using this software

6. REFERENCES

[1] G. Hua, W. Huang and H. Liu, "Accurate image registration method for PCB defects detection," in The Journal of Engineering, vol. 2018, no. 16, pp. 1662-1667, 11 2018, doi: 10.1049/joe.2018.8272

[2] J. P. R. Nayak, B. D. Parameshachari, K. M. S. Soyjaudah, Rajashekarappa, R. Banu and A. C. Nuthan, "Identification of PCB faults using image processing," 2017 International Conference on Electrical, Electronics, Communication, Computer, and Optimization Techniques, Mysuru, 2017, pp. 1-4, doi: 10.1109/ICEECCOT.2017.8284602.

[3] P. A. Nikam and S. D. Sawant, "Circuit board defect detection using image processing and microcontroller," 2017 International Conference on Intelligent Computing and Control Systems, Madurai, 2017, pp. 1096-1098, doi: 10.1109/ICCONS.2017.8250635.

[4] Z. Dong and L. Chen, "Image registration in PCB Fault Detection Based on Infrared Thermal Imaging," 2019 Chinese Control Conference (CCC), Guangzhou, China, 2019, pp. 4819-4823, doi: 10.23919/ChiCC.2019.8866191.

[5] S. Ren, L. Lu, L. Zhao and H. Duan, "Circuit board defect detection based on image processing," 2015 8th International Congress on Image and Signal Processing (CISP), Shenyang, 2015, pp. 899-903, doi: 10.1109/CISP.2015.7408005.

[6] J. A. Nahar and A. C. Phadke, "Computer Aided System for Inspection of Assembled PCB," 2019 International Conference on Intelligent Computing and Control Systems (ICCS), Madurai, India, 2019, pp. 372-376, doi: 10.1109/ICCS45141.2019.9065636.

[7] Hassanin, Abdel-Aziz IM, Fathi E. Abd El-Samie, and Ghada M. El Banby. "A real-time approach for automatic defect detection from PCBs based on SURF features and morphological operations." Multimedia Tools and Applications 78, no. 24 (2019): 34437-34457.

[8] Huang, Jing, Junnan Li, Lisang Liu, Kan Luo, Xiaoyong Chen, and Fenqiang Liang. "PCB Image Registration Based on a Priori Threshold SURF Algorithm." In International Conference on Smart Vehicular Technology, Transportation, Communication and Applications, pp. 440-447. Springer, Cham, 2018.

[9] Mukhopadhyay, Abhishek, L. R. D. Murthy, Manish Arora, Amaresh Chakrabarti, Imon Mukherjee, and Pradipta Biswas. "PCB Inspection in the Context of Smart Manufacturing." In Research into Design for a Connected World, pp. 655-663. Springer, Singapore, 2019.

[10] Anoop, K. P., N. S. Sarath, and VV Sasi Kumar. "A review of PCB defect detection using image processing." Intern. Journal of Engineering and Innovative Technology (IJEIT) 4, no. 11 (2015): 188-192.

[11] Wang, Wei-Chien, Shang-Liang Chen, Liang-Bi Chen, and Wan-Jung Chang. "A machine vision based automatic optical inspection system for measuring drilling quality of printed circuit boards." IEEE Access 5 (2016): 10817-10833.

[12] Ardhy, Faisal, and Farkhad Ihsan Hariadi. "Development of SBC based machine-vision system for PCB board assembly automatic optical inspection." In 2016 International Symposium on Electronics and Smart Devices (ISESD), pp. 386-393. IEEE, 2016.

[13] Zhang, Fen, Naosheng Qiao, and Jianfeng Li. "A PCB photoelectric image edge information detection method." Optik 144 : 642-646, Elsevier, 2017.

[14] Tao, Wenbin, Ying Xu, Hao Liu, Chengyong Wang, and Lijuan Zheng. "Machining accuracy detection of PCB hole by X-ray micro-CT." Micron 131 : 102826, Elsevier, 2020.

[15] Dai, Wenting, Abdul Mujeeb, Marius Erdt, and Alexei Sourin. "Soldering defect detection in automatic optical inspection." Advanced Engineering Informatics 43 : 101004, Elsevier, 2020.

[16] Asadizanjani, Navid, Mark Tehranipoor, and Domenic Forte. "PCB reverse engineering using nondestructive X-ray tomography and advanced image processing." IEEE Transactions on Components, Packaging and Manufacturing Technology 7, no. 2 (2017): 292-299.

[17] Bhardwaj, Anandita, and Pragya Varshney. "No-Reference Image Corrosion Detection of Printed Circuit Board." In Applications of Artificial Intelligence Techniques in Engineering, pp. 165-172. Springer, Singapore, 2019.

[18] Anitha, D. B., and Mahesh Rao. "A survey on defect detection in bare PCB and assembled PCB using image processing techniques." In 2017 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET), pp. 39-43. IEEE, 2017.

[19] Gaidhane, Vilas H., Yogesh V. Hote, and Vijander Singh. "An efficient similarity measure approach for PCB surface defect detection." Pattern Analysis and Applications 21, no. 1 : 277-289, Springer,2018.

[20] Zhang, Xuanni. "Online defect detection method of array optical sensor based on watershed image processing algorithm." Multimedia Tools and Applications :1-15, Springer, 2019.

[21] Cheong, Leong Kean, Shahrel Azmin Suandi, and Saimunur Rahman. "Defects and Components Recognition in Printed Circuit Boards Using Convolutional Neural Network." In 10th International Conference on Robotics, Vision, Signal Processing and Power Applications, pp. 75-81. Springer, Singapore, 2019.

[22] Moganti, Madhav, Fikret Ercal, Cihan H. Dagli, and Shou Tsunekawa. "Automatic PCB inspection algorithms: a survey." Computer vision and image understanding 63, no. 2 : 287-31, Elsevier, 1996.

[23] Putera, SH Indera, and Z. Ibrahim. "Printed circuit board defect detection using mathematical morphology and MATLAB image processing tools." In 2010 2nd International Conference on Education Technology and Computer, vol. 5, pp. V5-359. IEEE, 2010.