AUTOMATED FAULT DETECTION IN PCB

T.Y.Project Evaluation

Presented by :
Ishita Kothari : (Batch V2) - PA16
Prerana Kolipaka : (Batch A2) - PB26

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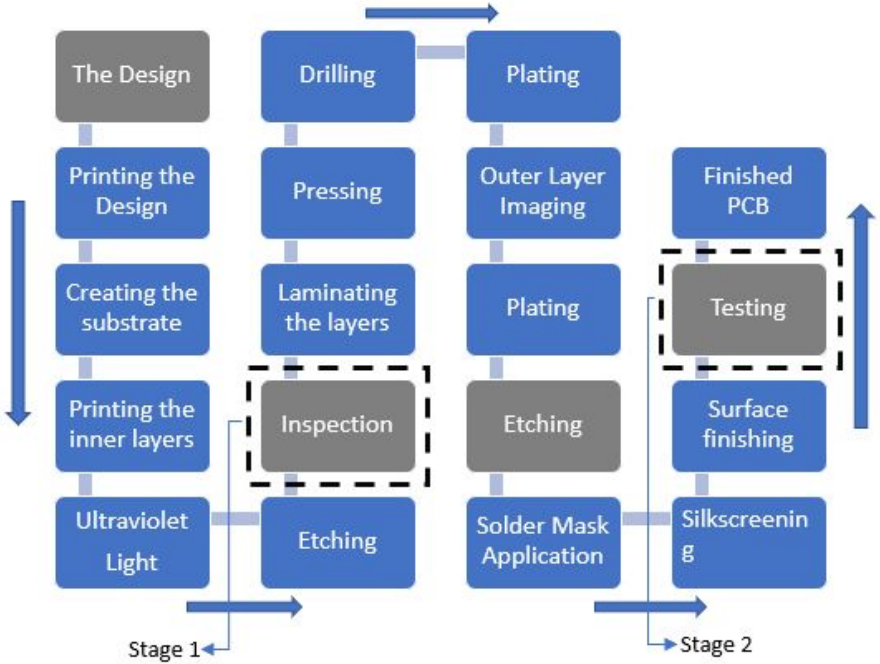
INTRODUCTION



PCB Fabrication Process

- Printed Circuit Board (PCB) fabrication process - multidisciplinary, multilevel and quite extensive
- High demand for zero defect PCB in market
- Complex processes involved in manufacturing of PCB such as cutting, drilling, printing, etching, masking, legend, v-scoring, tooling and quality inspection
- Defective boards lead to direct rejection

REVIEW OF LITERATURE

[1] Automatic PCB Defects Detection and Classification using Matlab by Prachi P. LondeÅ* and S. A. ChavanÅ EXTC Dept, DBNCOET Yavatmal, India. This project has investigated in the image processing topic. The intention of the current study was to detect and classify the Bare PCB Defect before etching as the etching costs 70% of the production cost. In order to measure the performance of this implementation, Accuracy was calculated and they got maximum accuracy in classifying all the defects as 80%, And the time required to classify is very less considering all the defects separately.

[2] PCB Fault Detection using image processing in Matlab by Shinde Sarika Sunil, Wankhede Shivraj Ambadas, Shete Supriya Gopinath, M.G.Chinchole. (Student, Department of E&TC, Sharadchandra Pawar College of Engg, India (MS) (Asst. Professor,Department of E&TC, Sharadchandra Pawar College of Engg, India (MS) In this paper, they have provided the implementation of a way to come across PCB errors and classify them through MATLAB. The technique suggests that it's miles feasible to apply the software and hit upon the errors present in PCB in order that further malfunction may be avoided. However, this technique is valid when components are not placed on the PCB.

[3] A Hybrid Approach for Detection and Classification of the Defects on Printed Circuit Board by Swagata Ray School of Education Technology, Jadavpur University, Kolkata and Joydeep Mukherjee, School of Education Technology, Jadavpur University, Kolkata. The work is successfully implemented on synthetically created image of PCB to detect, to classify and to locate the defects on PCB. By the proposed algorithm in this research work, the defects are detected and classified into five groups.

[4] "A Review on Defect Detection of SMT and Through Hole Components in Assembled PCB", INayana H G, Deepa P, Anitha D B, IVDr. Mahesh Rao I,IIM.Tech, Dept. of ECE, VVIET, Mysuru. Assosciate Professor, Dept. of ECE, VVIET, Mysuru. IVHOD & PG Coordinator, Dept. of ECE, MIT, Mysuru. This paper presents a review on the various existing approaches of automated assembled PCB. Also proposes the limitations still existing in this field. The pixel variations of various SMT components are explained in brief.

[5] Image Processing Based Defect Detection of Printed Circuit Board by Sanaullah Ahmad Rizvi1, K.B.Neelima2, Dr. T. Saravanan3 Bharath University, Chennai, India. This project aims at demonstrating real time PCB Defect Identification using digital image processing. The project involves the use of DIP and hence faults can be identified even before the components are soldered on the PCB.

OBJECTIVE

- To develop an algorithm to identify the defects and effectively localize them
- To classify the faults generated in a PCB during its fabrication process
- To use image processing techniques such as subtraction, alignment, XOR, thresholding, noise reduction, etc. to produce an output of the final testing image which will indicate the faults by comparing the test image with the reference image

SOFTWARES USED

KiCad

- Open source software suite for Electronic Design Automation
- Unlimited (No versions to choose from)
- Interactive routing, length matching, differential routing, are professional and industry grade
- Integration with Spice for simulation

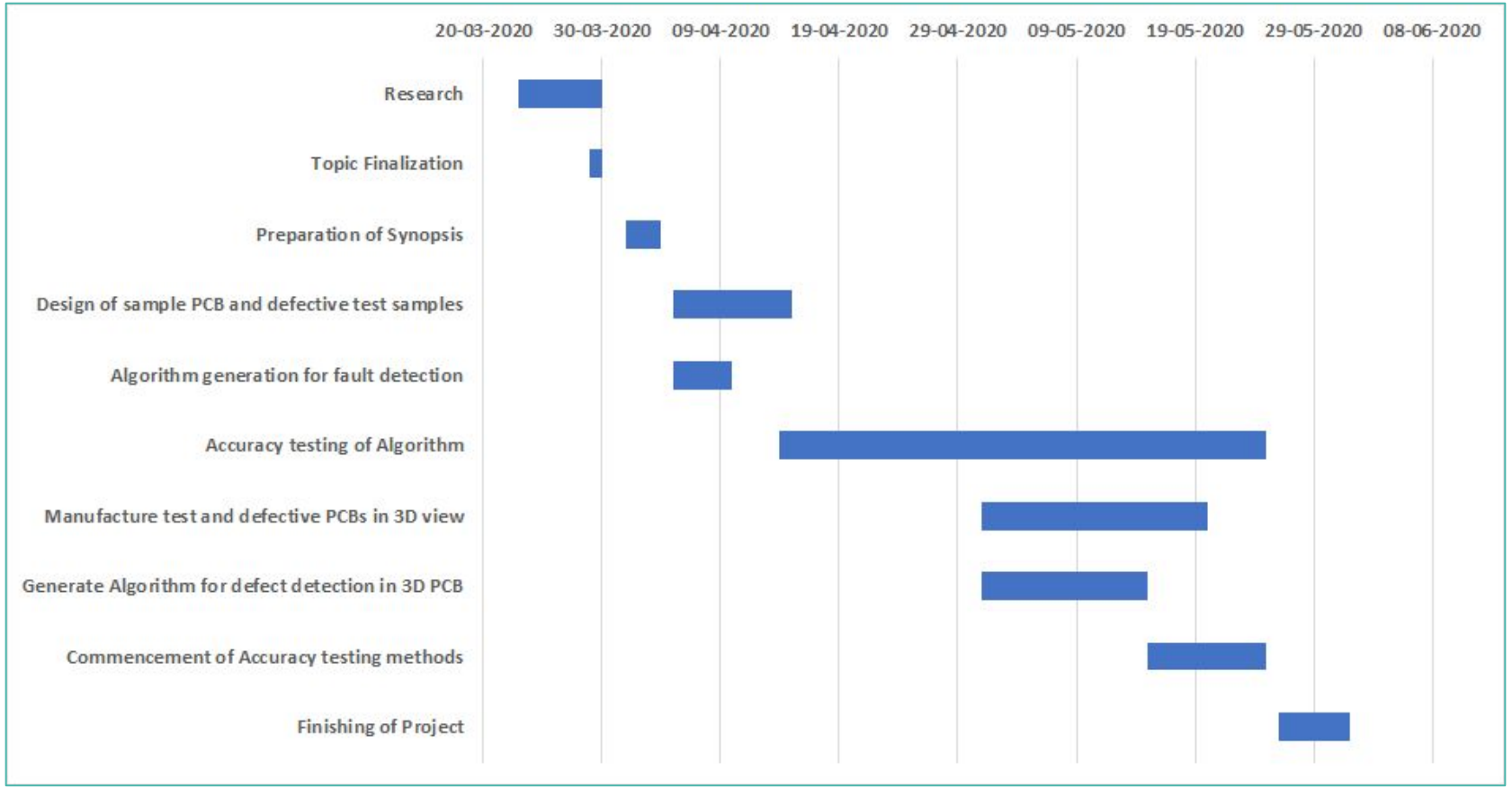
OpenCV

- Library of programming functions mainly aimed at real-time computer vision
- Open Source library
- Easy to integrate with other python libraries

ImageJ

- Java image processing program
- Open source software
- Various operations like image subtraction, applying filters, morphological operations, etc., can be performed.
- Results can be judged to develop algorithms.

GANTT CHART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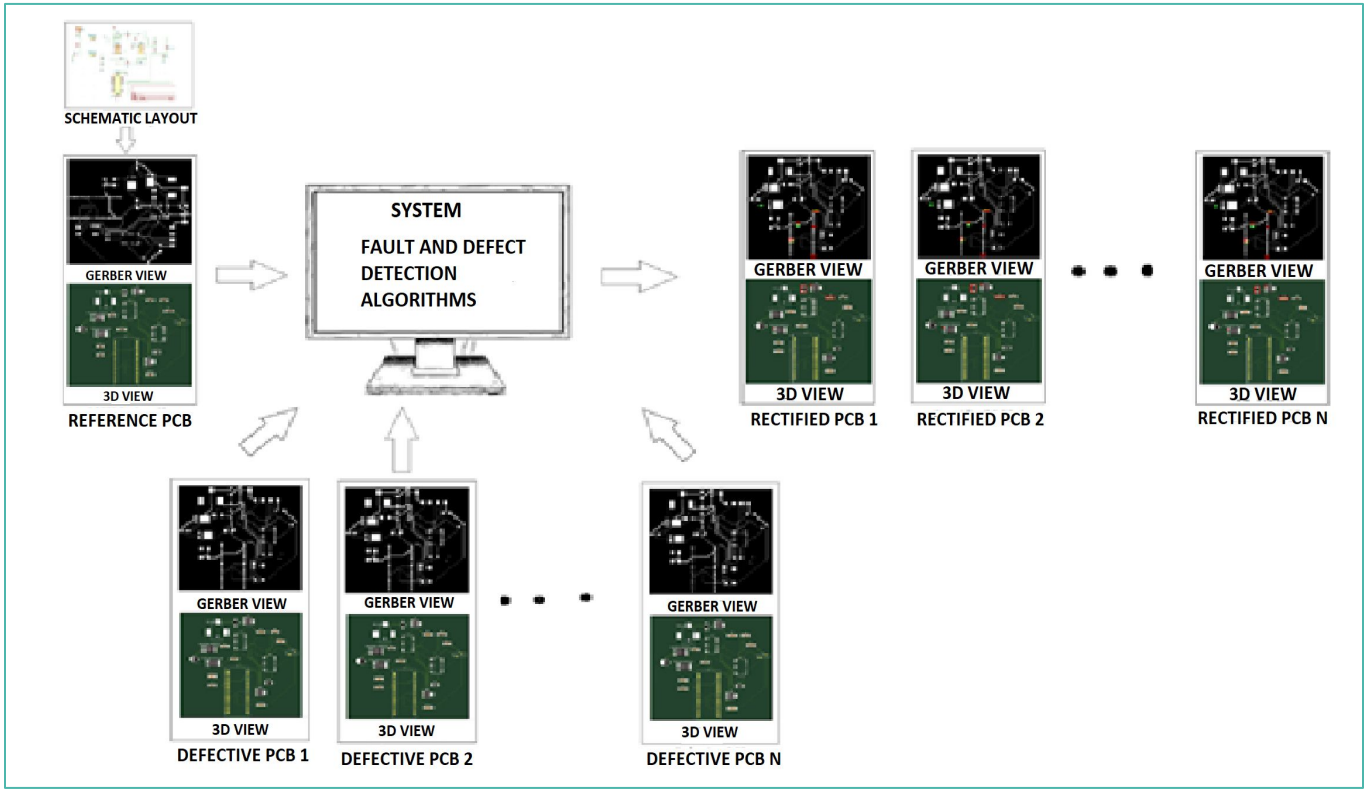
Research
Topic Finalization
Preparation of Synopsis
Design of sample PCB and defective test samples
Algorithm generation for fault detection
Accuracy testing of Algorithm
Manufacture test and defective PCBs in 3D view
Generate Algorithm for defect detection in 3D PCB
Commencement of Accuracy testing methods
Finishing of Project

BLOCK DIAGRAM



BLOCK DIAGRAM

This project can be divided into the following three parts -

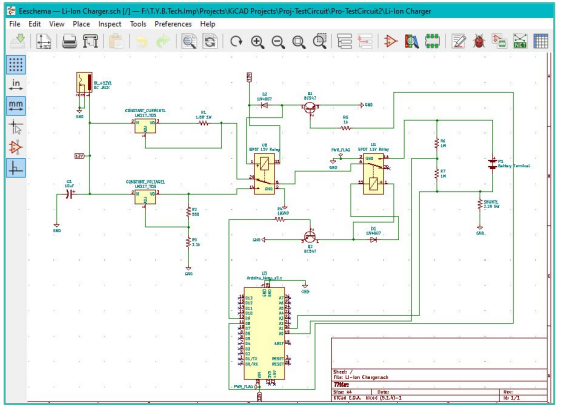
- **Part 1** - Designing a reference PCB and fabricating it

  Designed multiple PCBs which are to be inspected using design softwares Gerber View
- **Part 2 -** Acquiring reference images and test image

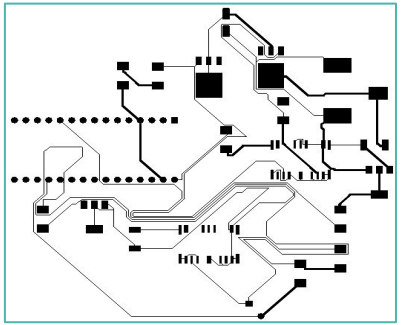
  Gerber View of PCBs for Stage 1 and 3D view of PCBs
- **Part 3** - Actual application of the detection algorithms
- **Output** - Rectified PCB image showing faults or defects if detected and classification of those defects

IMPLEMENTATION (1)

- 1.i. •Design of reference PCB in KiCad Software.
- 1.ii. •Application of DRC during schematic and layout stage.
- 1.iii •Generation of Gerber files. (for stage 1)
- 1.iv. •Generation of 3D view of reference PCB. (for stage 2)
- 1.v. •Designing multiple PCBs.
- 1.vi. •Generation of Gerber files and 3D view of these PCBs
- 1.vii •Designing of multiple PCB's of same circuit
- 1.viii •Fabrication of multiple PCB's



Test circuit PCB layout in KiCad



Test circuit Gerber view in KiCad

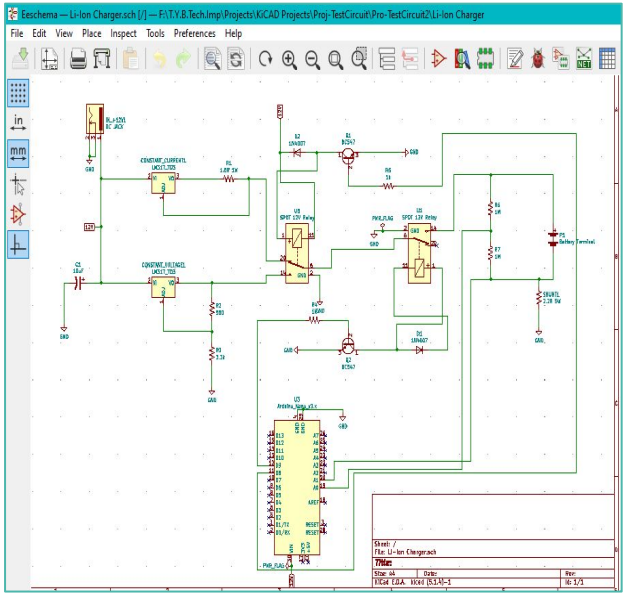


Image 1:
Schematic Layout of PCB in KiCad

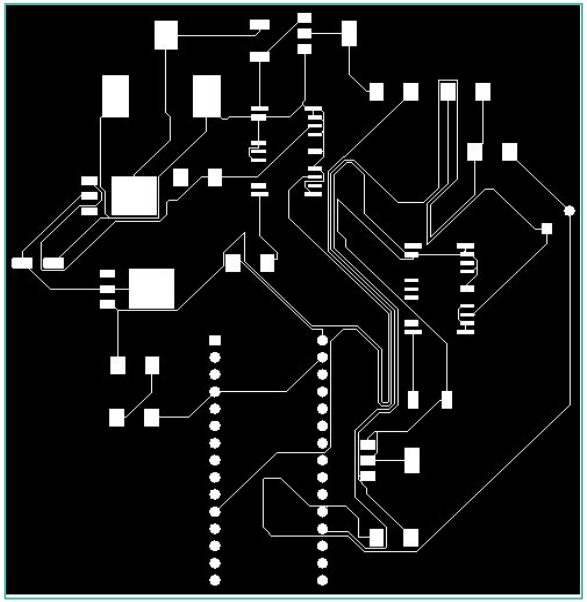


Image 2:
Gerber view of PCB in KiCad

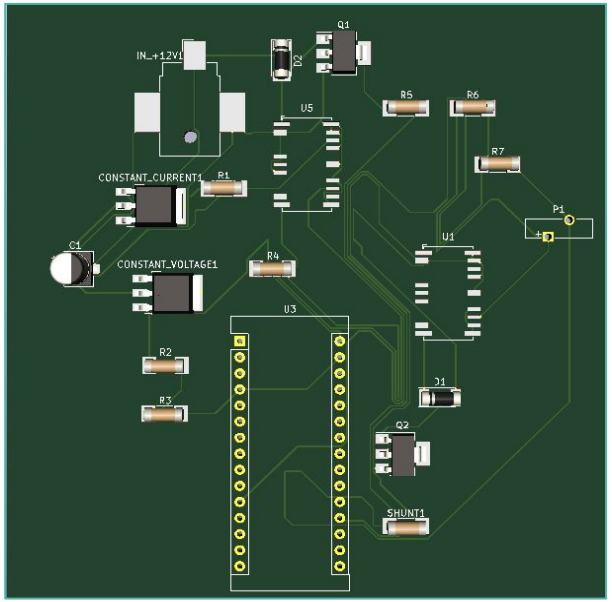
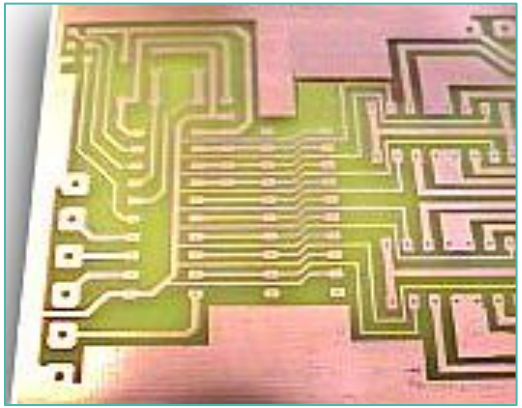


Image 3:
3D view of PCB in KiCad

IMPLEMENTATION (2)

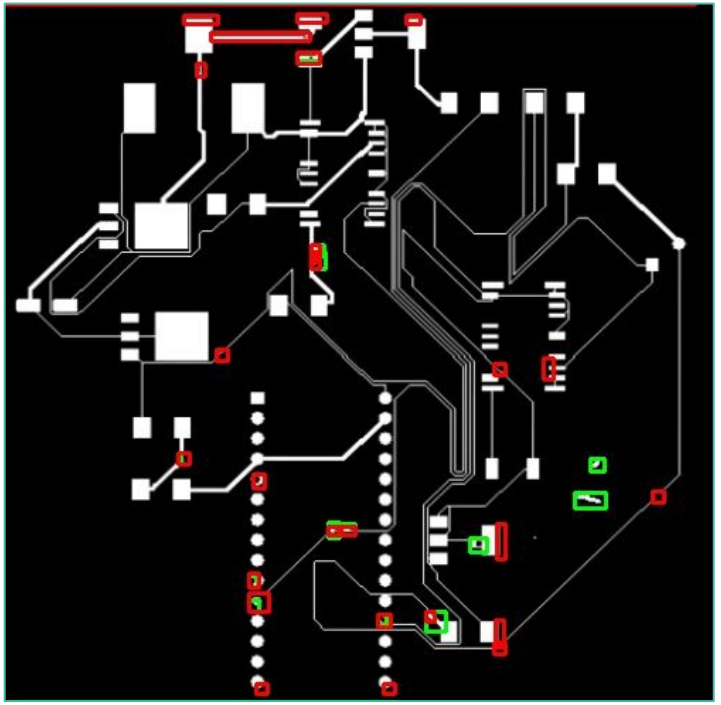
Fault detection at Stage 1 :

- 2.i. •Use the image of Gerber view of Reference PCB as the ideal image
- 2.ii. •Feed image to system
- 2.iii. •Comparison of Reference image and new PCB layout
- 2.iv. •Detection of defects and faults in PCB layout
- 2.v. •Rectification (if any)
- 2.vi. •Fabrication of rectified PCB's



CLASSIFICATION OF DEFECTS

Sr. No.	Defect	Missing Copper	Extra Copper
1	Breakout	✓	
2	Pinhole	✓	
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	✓	



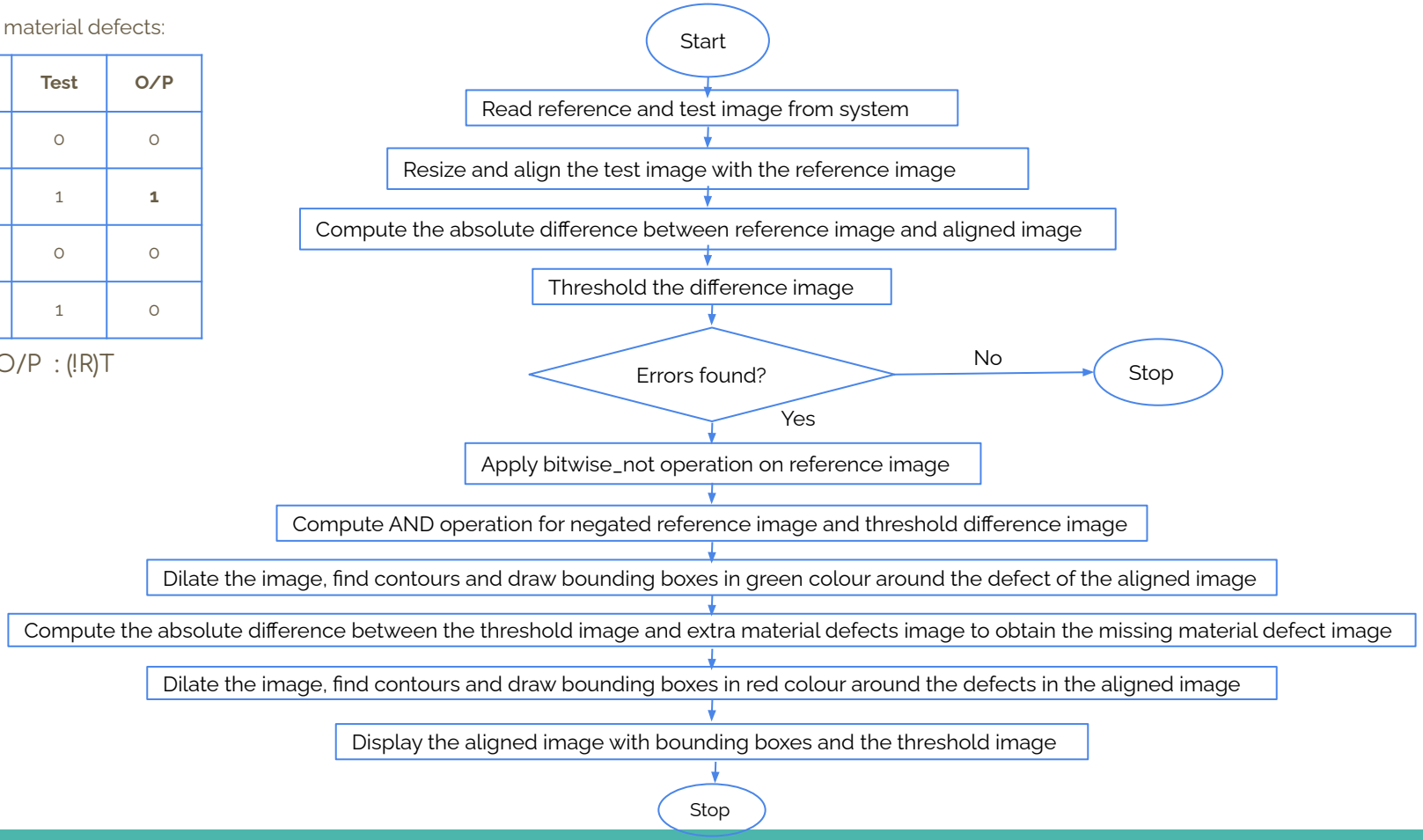
Classification of Defects
(Red box: Missing Copper
Green Box: Extra Copper)

ALGORITHM FOR STAGE 1

For extra material defects:

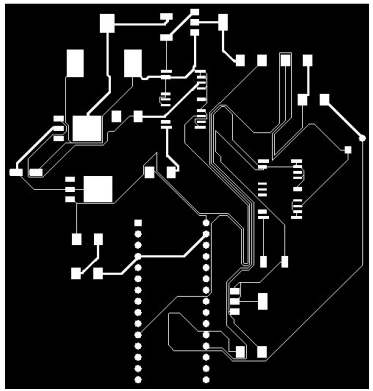
Ref	Test	O/P
0	0	0
0	1	**1**
1	0	0
1	1	0

O/P : (!R)T

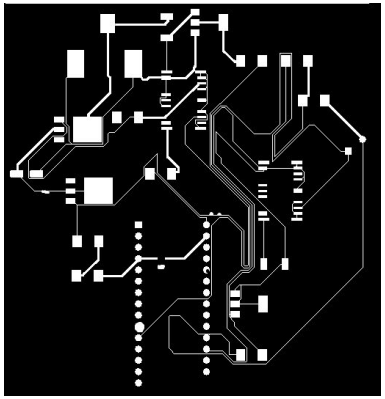


SIMULATION RESULTS - STAGE 1

INPUT:

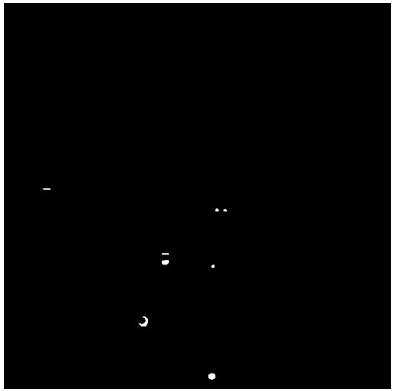


Gerber view of Reference PCB

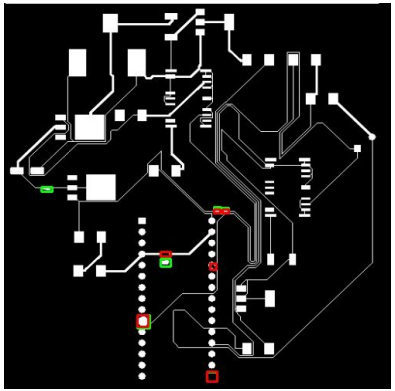


Gerber View of Test PCB

OUTPUT:



Difference Image

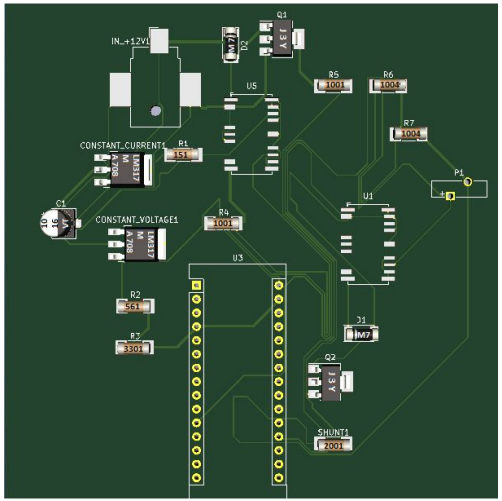


Classification of Defects

IMPLEMENTATION (3)

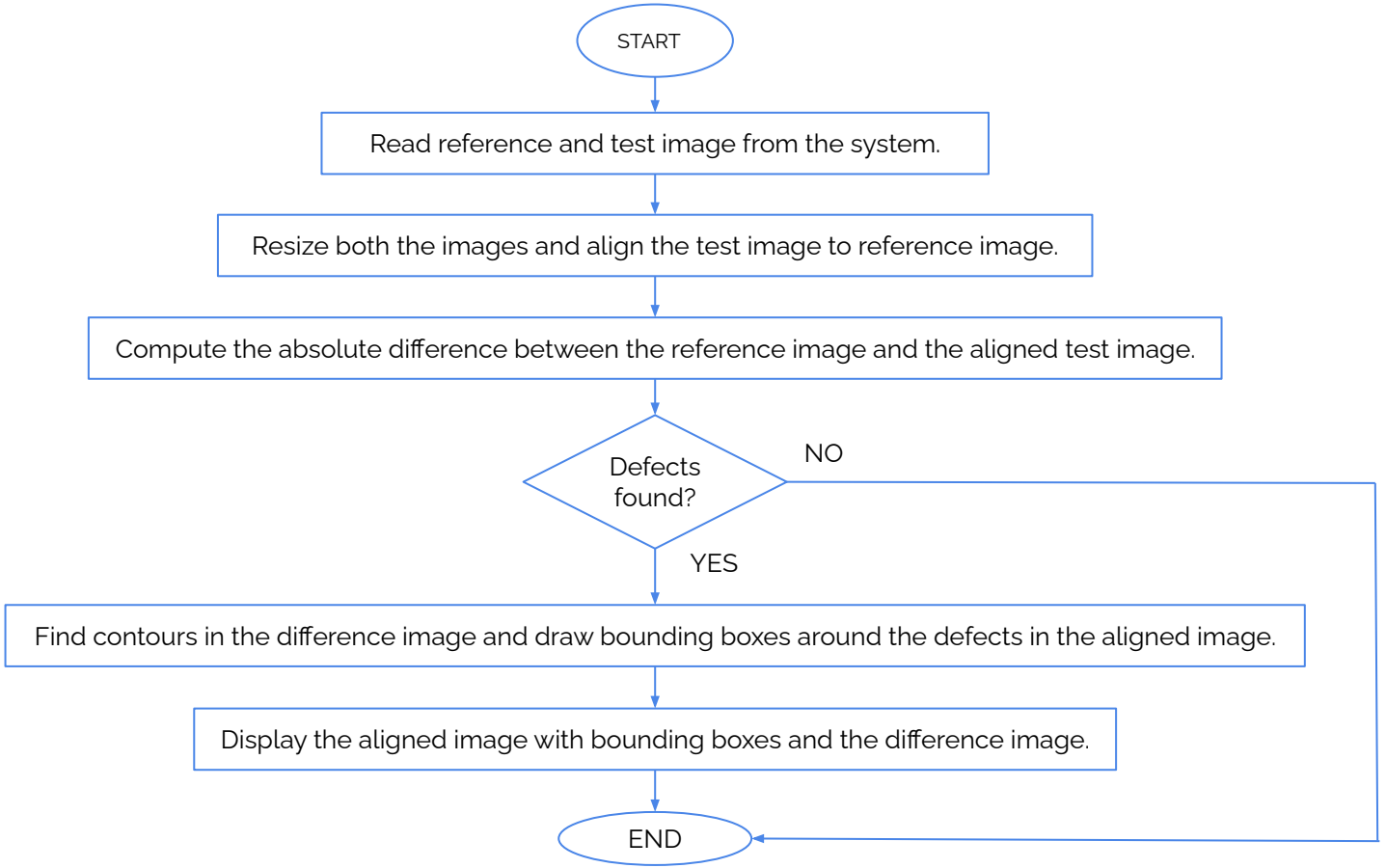
Fault detection at Stage 2 :

- 3.i. •Use the image of 3D view of PCB as the ideal image
- 3.ii. •Feed image to system
- 3.iii. •Comparison of reference image and 3D view of new PCB
- 3.iv. •Detection of defects and faults in PCB
- 3.v. •Display faults and defects if any as a new image
- 3.vi. •Rectification (if any)
- 3.vii. •Fabricating the rectified PCB



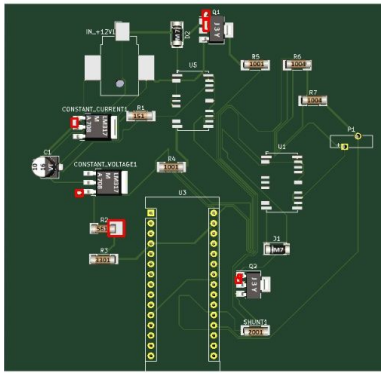
3D view (considered as captured image of PCB in software simulation)

ALGORITHM FOR STAGE 2

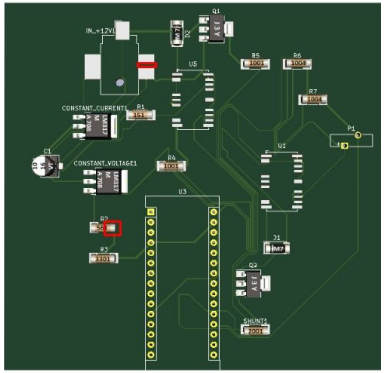


DEFECTS - STAGE 2

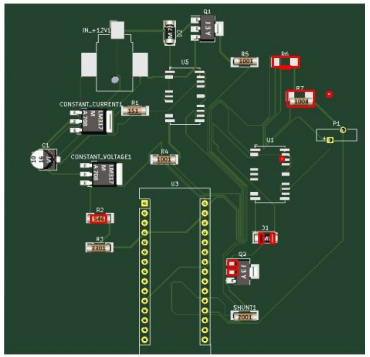
Sr. No.	Defects	Excess Copper Defects	Less Copper Defects	Component Related Defects
1	Solder Projection	√		
2	Solder Splashes	√		
3	Solder balls	√		
4	Excess solder	√		
5	Solder short	√		
6	Solder bridge	√		
7	Less solder		√	
8	Open Solder joints		√	
9	Missing Component			√
10	Component Shift			√
11	Component Lift			√
12	Component Damage			√
13	Component Polarity			√
14	Wrong Component			√



Defects 1-6



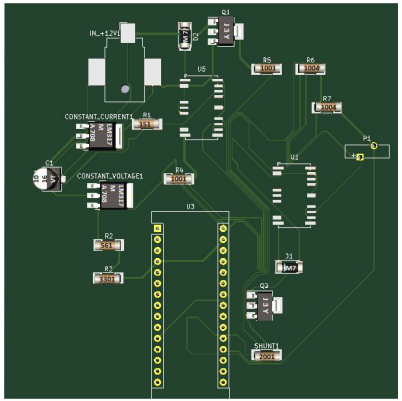
Defects 7-8



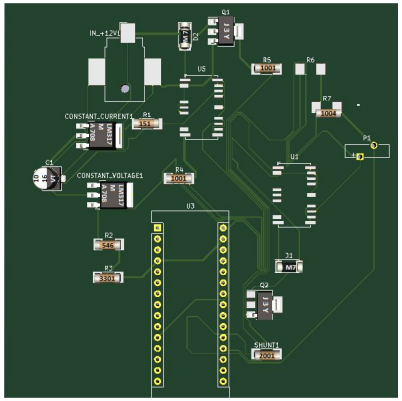
Defects 9 -14

SIMULATION RESULTS - STAGE 2

INPUT:

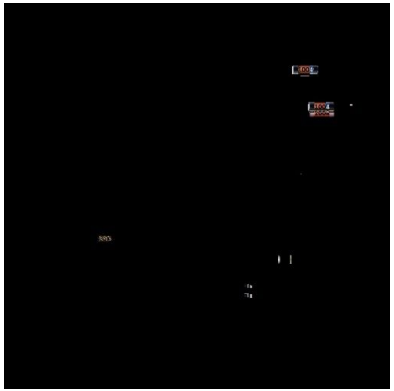


3D view of Reference PCB

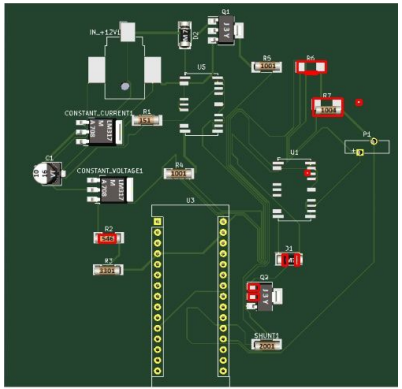


3D view of Test PCB

OUTPUT:



Difference image of PCB



Defect detected in PCB

ACCURACY RESULTS - STAGE 1

Accuracy of Fault Detection Algorithm in Stage 1

Sr. No.	DEFECTS	Sample 1		Sample 2		Sample 3		Sample 4		Sample 5		Sample 6		Sample 7	
		P	D	P	D	P	D	P	D	P	D	P	D	P	D
1	Breakout	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗
2	Pinhole	✓	✓	✓	✓	✗	✗	✗	✗	✓	✓	✓	✓	✗	✗
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	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗

*P: Presence of the defect
D: Defect Detection

Accuracy of Fault Detection Algorithm in Stage 1

Sr. No.	DEFECTS	Sample 8		Sample 9		Sample 10		Sample 11		Sample 12		Sample 13		Sample 14		Sample 15	
		P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D
1	Breakout	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✓	✓	✗	✗	✓	✓
2	Pinhole	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓
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	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗

*P: Presence of the defect
D: Defect Detection

RESULTS:

Sr. No.	Parameter	Value
1	No. of Reference PCBs generated (Gerber view)	1
2	No. of Test PCBs generated (Defective)	15
3	No. of Errors present in all PCBs cumulatively	77
4	No. of Errors detected in all PCBs cumulatively	75
5	**Percentage Accuracy**	**97.40 %**

ACCURACY RESULTS - STAGE 2

Accuracy of Fault Detection Algorithm in Stage 2

Sr. No.	DEFECTS	Sample 1		Sample 2		Sample 3		Sample 4		Sample 5		Sample 6		Sample 7	
		P	D	P	D	P	D	P	D	P	D	P	D	P	D
1	Solder Projection	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
2	Solder Splashes	✗	✗	✓	✓	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓
3	Solder Balls	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
4	Excess solder	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
5	Solder short	✗	✗	✓	✓	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓
6	Solder Bridge	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗	✗
7	Less solder	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✓	✓	✗	✗
8	Open solder Joints	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
9	Missing Component	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗	✗
10	Component Shift	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗
11	Component Lift	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
12	Component Damage	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓
13	Component Polarity	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
14	Wrong component	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✗	✗	✗	✗

*P: Presence of the defect
D: Defect Detection

Accuracy of Fault Detection Algorithm in Stage 2

Sr. No.	DEFECTS	Sample 8		Sample 9		Sample 10		Sample 11		Sample 12		Sample 13		Sample 14		Sample 15	
		P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D
1	Solder Projection	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗	✗
2	Solder Splashes	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗	✗	✓	✓	✗	✗
3	Solder Balls	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✗	✗
4	Excess solder	✗	✗	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗	✗
5	Solder short	✗	✗	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✓	✓	✗	✗
6	Solder Bridge	✓	✓	✗	✗	✓	✓	✗	✗	✓	✓	✗	✗	✓	✓	✗	✗
7	Less solder	✓	✓	✗	✗	✗	✗	✓	✓	✓	✓	✗	✗	✗	✗	✓	✓
8	Open solder Joints	✗	✗	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓
9	Missing Component	✓	✓	✗	✗	✓	✓	✗	✗	✓	✓	✓	✓	✗	✗	✗	✗
10	Component Shift	✗	✗	✓	✓	✗	✗	✓	✓	✗	✗	✓	✓	✗	✗	✗	✗
11	Component Lift	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
12	Component Damage	✗	✗	✓	✓	✗	✗	✓	✓	✗	✗	✓	✓	✗	✗	✗	✗
13	Component Polarity	✓	✓	✗	✗	✓	✓	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗
14	Wrong component	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗

*P: Presence of the defect
D: Defect Detection

RESULTS:

Sr. No.	Parameter	Value
1	No. of Reference PCBs generated (3D view)	1
2	No. of Test PCBs generated (Defective)	15
3	No. of Errors present in all PCBs cumulatively	56
4	No. of Errors detected in all PCBs cumulatively	56
5	**Percentage Accuracy**	**100 %**

CHALLENGES FACED

Sr. No.	Challenges Faced	Steps taken to overcome challenges
1	Lack of PCB Fabrication Resources	Devised methods to implement algorithm without an actual PCB
2	Capturing PCB layout image through Camera and Microcontroller for stage 1	Used the Gerber Views of PCB
3	Capturing PCB layout image through Camera and Microcontroller for stage 2	Used 3D View of PCB
4	Limited demonstration of 3D defects (stage 2 errors) eg. Component Lift, Solder Projection	Demonstrated and detected all remaining defects

ADVANTAGES

- Verification of whether the characteristics of board manufacturing are in conformity with design specifications
- Algorithm works on loaded (components present) PCB's
- Reduction in cost
- Increase in accuracy
- Reduced manual effort and errors
- Easier and faster defect detection
- All defects are localized properly
- Classification accuracy is good

CONSTRAINTS

- This algorithm works fine for system generated images, The accuracy may vary when applied to images captured through a camera.
- The algorithm will have to be improved for camera captured images as a lot of error adds in due to:
  - Quality of image captured
  - Lighting condition
  - Misalignment
  - No.of angles considered for capturing image
- Classification of defects do not take place at stage 2.

FUTURE SCOPE

- The approach shown in this project has been implemented on the synthetically created images of PCB only due to resource constraints. But, this proposed algorithm can be implemented on the digital photos of PCB which are clicked by digital camera at different angles.
- Robust algorithms could be developed in classifying the defects after the PCB has been manufactured, with the components soldered.
- Make algorithm efficient enough to detect changes in case of different lighting conditions and even for low quality images

REFERENCES

[1] Automatic PCB Defects Detection and Classification using Matlab by Prachi P. LondeÅ* and S. A. ChavanÅ EXTC Dept, DBNCOET Yavatmal, India.

[2] PCB Fault Detection using image processing in Matlab by Shinde Sarika Sunil, Wankhede Shivraj Ambadas, Shete Supriya Gopinath, M.G.Chinchole. (Student, Department of E&TC, Sharadchandra Pawar College of Engg, India (MS) (Asst. Professor,Department of E&TC, Sharadchandra Pawar College of Engg, India (MS)

[3] A Hybrid Approach for Detection and Classification of the Defects on Printed Circuit Board by Swagata Ray School of Education Technology, Jadavpur University, Kolkata and Joydeep Mukherjee, School of Education Technology, Jadavpur University, Kolkata.

[4] "A Review on Defect Detection of SMT and Through Hole Components in Assembled PCB", INayana H G, Deepa P, Anitha D B, IVDr. Mahesh Rao I,IIM.Tech, Dept. of ECE, VVIET, Mysuru. Assosciate Professor, Dept. of ECE, VVIET, Mysuru. IVHOD & PG Coordinator, Dept. of ECE, MIT, Mysuru.

[5] Image Processing Based Defect Detection of Printed Circuit Board by Sanaullah Ahmad Rizvi1, K.B.Neelima2, Dr. T. Saravanan3 Bharath University, Chennai, India. This project aims at demonstrating real time PCB Defect Identification using digital image processing.

[6] https://www.candorind.com/pcb-manufacturing-process/

[7] https://www.researchgate.net/post/Can_anyone_recommend_software_for_image_processing_other_than_matlab

THANK YOU!