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Fault Detection in PCB using Machine Learning

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ABSTRACT—

Printed Circuit Boards are the essential part of various industries. The whole functioning of any electronic device is dependent on the PCBs. But in PCB manufacturing process, the problem faced by the manufacturers is defected PCBs. The common PCB defects are opens, shorts, copper exposure, nodules, missing components, etc. Use of such faulty PCBs can damage the device and will result in device failure. As some PCBs are very small in size, it is difficult to find out the faults in PCBs manually. Authors presented papers related to the fault detection in PCBs using different techniques such as image processing, machine learning. Traditional detections algorithms have low accuracy and high errors. The project presented here is based on machine learning algorithm with high accuracy. Convolutional Neural Network is used for object detection and classification. The system classifies the input image of PCB as defected or defect free by detecting the faults on it.

***Index Terms*—object detection, convolutional neural network, YOLO, PCB**

I. INTRODUCTION

The manufacturing of printed circuit boards (PCBs) is a market that is expanding quickly. PCB manufacturing is an extremely accurate and complicated procedure. There are instances where the PCBs were improperly produced frequently. The most frequent causes of bad PCBs include track problems, missing components, and component orientation. Either human error or a calibration issue with the assembler is to blame for these errors. Sometimes the component is oriented incorrectly. These mistakes have a substantial impact on the functionality and longevity of the goods or electronic equipment that the PCBs are intended to be fitted into, and they even have the potential to cause PCB failure. This causes serious issues. Determining the PCB design flaws is therefore important in order to solve such issues. Traditional production line firms introduce appropriate detection procedures to finish fault detection in order to achieve precise PCB assembly. Traditional target defect algorithms, however, frequently have poor detection accuracy and large error rates. Therefore, it is essential to develop a system that is both effective and efficient for solving this problem.

Technology has made such great strides in recent years, digitizing everything, cutting the time required to do specific operations, and improve system efficiency. Finding flaws is essential for assuring product quality. The market for industrial automation is growing due to the widespread use of cameras and the accessibility of machine vision systems, so the process of defect detection and categorization of printed circuit boards should also be automated to save time, increase system efficiency, and lower costs. The project described here receives an image as input, examines it, finds various types of flaws like openings, shorts, and missing holes in the printed circuit board, and then categorizes it as defective or non-defective.

II. LITERATURE SURVEY

A. Related works

Manasa H.R., [1] proposed a solution to detect defects in PCB using Lab-VIEW. Original PCB image and the image we both need to test is captured in color format. Then captured images are converted to a field are compared to each other in a tabular format. This the work uses a binary classification technique to classify the test pictures like “failed” or “passed”. S. H. InderaPutera, [2] proposed method for classifying single-layer PCBs as under etching, via etching, short circuit, open circuit, etc. Algorithm used in this paper uses morphological techniques, image subtraction, image segmentation and logic gates to find defects and classify them accordingly. The solution classified 13 defects but with the disadvantage of generating false positive images to the noise. Paper presented at the 5th International Conference 2020 [3] on mechanical, control and computer engineering: “Research on PCB Defect Detection Using Deep Convolution Neural Network’ uses PCB defect detection and recognition an algorithm based on a deep convolutional network framework SSD. The system is developed to find errors such as nodes, copper exposure and copper scratches. The algorithm has a significant improvement in accuracy PCB defect detection, i.e. 94.69% accuracy. Paper presented in 2018 4th International Conference on Signal Frontiers Processing [4]. Creation of

an automatic defect verification system tem using a deep neural network for the classification of DPS defects presents algorithms that are based on pixel and object theory detections that were used in combination to optimize results from a given data set. Detects malfunctions such as opening, shorts and mouse bites. Neural network used for detection and the classification here is YOLO. The accuracy achieved by this algorithm is 75.68%.

III. CONCEPTUAL FRAMEWORK

A conceptual framework for fault detection using machine learning can be developed to enhance the assessment system of PCB quality. This conceptual framework consists of the fol- lowing phases: (A) analysis of PCB defects (B) identification of usable algorithms, (C) training and validation of developed algorithms, and (D) test operations.

A. Analysis of PCB defects

Printed circuit boards can have many defects like opens, shorts, copper scratches, copper exposure, holes etc, which can possibly introduce many kinds of errors when used across different systems.

1) *Opens:* Discontinuity or non-connections. Fig.1 shows the open track in PCB

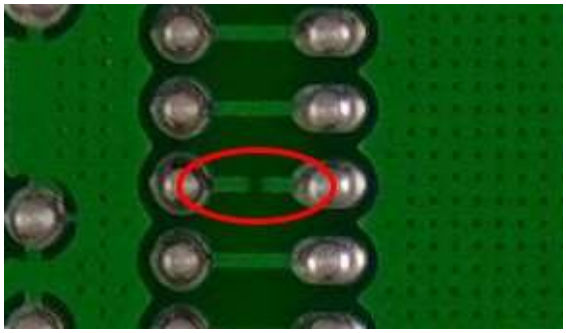

Fig. 1. Opens

2) *Shorts:* Connection between two or more nets or isolated points that should not be connected. Fig. 2 shows the shorts between two tracks on PCB

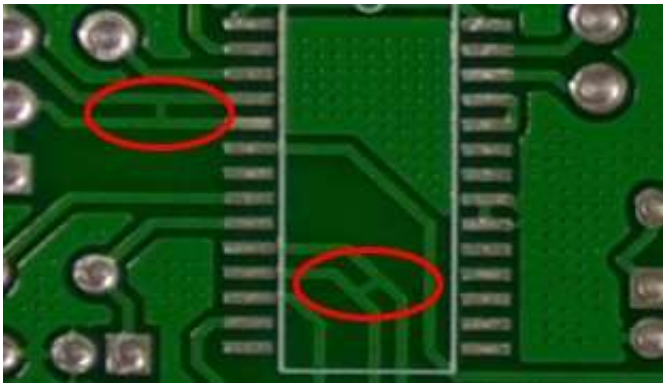

Fig. 2. Shorts

3) *Copper scratches:* Due to copper scratches, current flow gets affected. Fig. 3 shows the copper scratch on PCB.

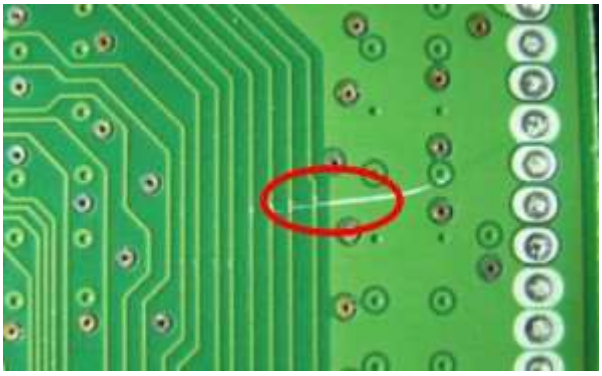

Fig. 3. Copper scratches

4) *Copper exposure:* Excess copper is present on unwanted part. Fig. 4 shows the excess amount of copper present.

Fig. 4. Copper exposure

B. Identification of algorithm

We can determine the necessary method for classification and defect detection by analyzing the various PCB flaws. Given the numerous properties, selecting an appropriate algorithm is a challenging task. For object detection and classification, a number of methods are available, including CNN, Single Shot Director, YOLO, and Fast R-CNN.

C. Training and validation of the algorithm

The next stage of the proposed methodology is algorithm training and validation. Training and validation should be done prior to applying the methodology in final operations. To improve the accuracy of your system, you should train it with as much data as you can.

D. Test operations

The trained algorithm should be checked after training and validation by using a PCB picture as input to see if it can accurately identify the inserted faults and classify the PCB as faulty or non-defective.

IV. METHODOLOGY

a) Data Preprocessing

The pre-processing technique is applied to the datasets of photos that we first acquire, which include both faulty and non-defective images. Pre-processing of input image data is done to convert it into meaningful floating-point tensors for feeding into CNN. Then, using existing data to create new data points, we enhance the original dataset to artificially increase the amount of data.

b) Algorithm

YOLO is an acronym for the words “You Only Look Once”. It uses a convolutional neural network (CNN) to detect objects in real-time

1) Reasons for YOLO algorithm to be implemented:

- Speed: Object detection speed is improved so that objects can be predicted in real time.
- High accuracy: It provides accurate results with minimal background errors
- Learning capabilities: This algorithm has an amazing learning ability that allows it to learn representations of objects

2) working:

- The YOLO design enables continuous training of the model. It also has real-time speed while maintaining a high average accuracy score
- First, divide the given input image into an S × S grid. If the object’s center is within a grid cell, that grid cell is responsible for detecting that object
- Each grid cell predicts bounding boxes and confidence values for those boxes. These confidence values reflect the accuracy of the model that the box contains the object. It also indicates how accurate you think the box you are predicting is

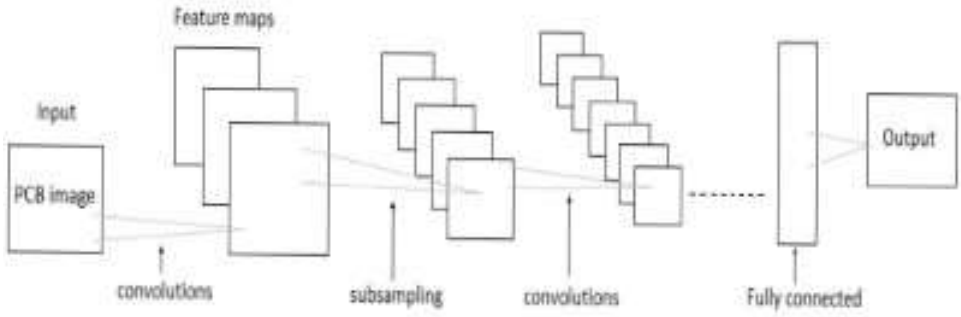

Fig. 5. Architecture of YOLO algorithm

c) Results and discussions

After training and validation of the algorithm following results can be observed on the test input image as follows

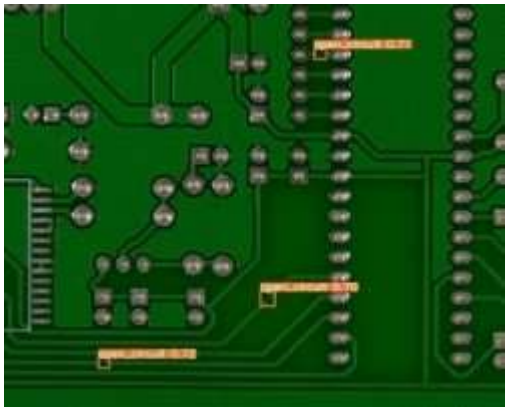

Fig. 6. Detected faults

Table 1: PRECISION ANALYSIS TABLE OF PCB DEFECTS DETECTION

Type of defects	precision
Missing hole	0.986
Mouse bite	0.848
Open circuit	0.803
Short	0.918
Spur	0.856
Spurious copper	0.796

Following Curve summarizes the trade-off between the true positive rate and false positive rate for the predictive model using different probability thresholds.

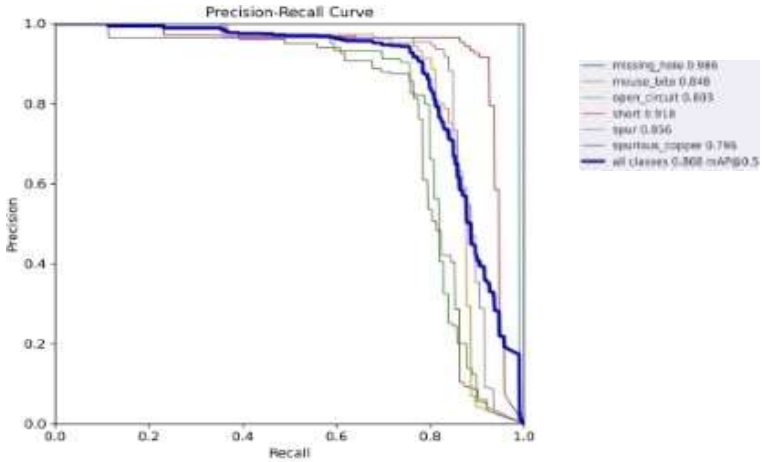

Fig. 7. Precision recall curve

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