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DEEP LEARNING FOR FLAWS IN PCB DESIGN

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Abstract - *The importance of the Printed Circuit Board inspection process has been magnified by requirements of the modern manufacturing environment where delivery of 100% defect free PCBs is the expectation. To meet such expectations, identifying various defects and their types becomes the first step. In this PCB inspection system the inspection algorithm mainly focuses on the defect detection using the natural images. Many practical issues like tilt of the images, bad light conditions, height at which images are taken etc. are to be considered to ensure good quality of the image which can then be used for defect detection. Printed circuit board (PCB) fabrication is a multidisciplinary process, and etching is the most critical part in the PCB manufacturing process. The main objective of Etching process is to remove the exposed unwanted copper other than the required circuit pattern. In order to minimize scrap caused by the wrongly etched PCB panel, inspection has to be done in ear7ly stage. However, all of the inspections are done after the etching process where any defective PCB found is no longer useful and is simply thrown away. Since etching process costs 0% of the entire PCB fabrication, it is uneconomical to simply discard the defective PCBs. In this paper a method to identify the defects in natural PCB images and associated practical issues are addressed using Software tools and some of the major types of single layer PCB defects are Pattern Cut, Pin hole, Pattern Short, Nick etc., Therefore the defects should be identified before the etching process so that the PCB would be reprocessed. In the present approach expected to improve the efficiency of the system in detecting the defects even in low quality images*

***Key Words*: PCB, Flaw detection, CNN, Image processing, Manufacturing**

1. INTRODUCTION

The Printed Circuit Board (PCB) is an insulated board which consists of conduction lines printed or padded to its surface and the electrical and electronic components are physically mounted on the board for connection. The conversion of a schematic diagram to its equal physical board layout including routing between all the components is the process involved in PCB design. The most common troubles when designing the PCB include solder joint defects, incorrect component landing pattern, blind or buried vias and insufficient trace width.

1.1Analysis:

Printed Circuit Boards form the basis of virtually all electronic circuits. They provide the mechanical basis in which the circuit is built. A desired image layout is made on a copper clad laminate and excess of copper from the inner layers is etched using inks to reveal the traces and pads. Generally a solder mask film is given on both the sides to protect the copper on the fiberglass core and to prevent short circuits. All the layers are bound tightly for a secure fit

2. FLAWS IN PCB DESIGN:

2.1 Solder Joint Defects:

This includes Open Solder Joints where there is no bonding between the padding and the lead or any other connection which results in an open connection. By ensuring correct aspect ratio i.e, the ratio of aperture width to board thickness this could be avoided. Shorts or Solder Bridging occurs when the solder is inter-crossed with one and another. This could cause heavy damage when unattended such as burn up of a Component or the PCB pads. This can be prevented if an appropriate reflow profile is used. Component shift occurs when the position of the component shifts due to surface tension of a molten solder. This can be avoided if the accuracy of component placement by pick and place machines is improved.

2.2 Incorrect Landing Pattern:

The schematic diagram and footprint/ landing pattern of commonly used electronic components are found in the libraries which are included in the PCB design software. In case of components not present in these libraries, we have to manually draw them. This could be easily overseen because if the pin to pin spacing is off, even by a millimeter, the device will not be soldered properly to the board. By cautiously drawing the correct specifications and including the essential data this defect can be prevented.

2.3 Blind/ Buried Vias:

Mostly Vias go through all the layers in a PCB Board. To keep the board size small and compact, blind and buried vias are used as these reduce the board's footprint and area. While they effectively compact the board, they also reduce the routing space thus making the circuit more complex and not manufacturable.

2.4 Insufficient Trace Width:

A PCB track's width should be able to support its current carrying capability. A track's width also depends upon thickness of copper and the internal and external layer. Designing a smaller and compact PCB with lesser track width and more milliamps of current will result in excess temperature rise. This can be avoided by using a trace width calculator which will determine the required thickness and ensure design accuracy.

Image processing can be used in place of human inspection for detecting the flaws in PCB design. As the need for electronics increases every day, the circuit becomes more compact and complex. Therefore, Image processing in place of tedious manual inspection has more advantages as it detects the errors in the circuit board much quickly and efficiently.

3. Literature Survey:

There are various methods to inspect the flaws in the Printed Design. Manual inspection takes more time and effort and yields poor results. An Automated Optical Inspection is much preferred for flaw detection in PCB as it takes less amount of time and yields more precise results. PCB flaw detection based PCB inspection based on a variant of the n-tuple technique proposed by Ouslim helps to detect small defects in electronic printed circuit boards. This technique operates on a list of nine attributes formed in a 3 by 3 kernel. Automated inspection of printed circuit boards through machine vision by Wen-Yen Wu developed an automated visual inspection system for detection of PCB. This direct subtraction of the reference to the test image to produce Positive (P), Negative (N) and Equal (E) pixels Later, defect classification is done based on P, N and E pixels. Currently the PCB is inspected either for component or track inspection of fabricated PCB. It is also necessary to classify and locate these defects so that the source and location of these defects can be identified.

4. Proposed Idea:

An interconnected collection of nodes and perceptrons constitute a neural network in deep learning. Every neuron takes an input of one unit of data and then applies computation known as activation function to derive the required result. Neural networks used in image processing and recognition are employed in PCB manufacturing units where its purpose is to detect errors and defects in the design and routing process. Neural Networks store images of electronic components with its related metadata thereby automatically detecting flaws in PCB design

5. IMPLEMENTATION OF YOLO IN PCB FLAW DETECTION:

YOLO (You Only Look Once) is an efficient model used for Object detection. It is much faster and effective than Faster R-CNN (Region based Convolutional Neural Network). The architecture of YOLO is much simpler and has an advantage of performing both image classification and bounding box regression simultaneously. It can classify more than one object in a single picture. The methodology consists of a single neural network trained end to end which takes an image as an input and splits the image into a group of cells and later predicts the class labels for each bounding box directly. A class prediction is also based on each cell. Images of all the probable defects are fed and saved as reference images and then the image of the PCB design is fed as the input. The images are compared and the defect or flaw is detected.

5.1 Idea Subtitle:

5.1.1 Math and computation

5.1.1 Algorithm development

5.1.2 Data acquisition

5.1.3 Modeling, simulation, and prototyping

5.1.4 Data analysis, exploration, and visualization

5.1.5 Scientific and engineering graphics

5.1.6 Application development, including graphical user interface building

5.2 YOLO V5:

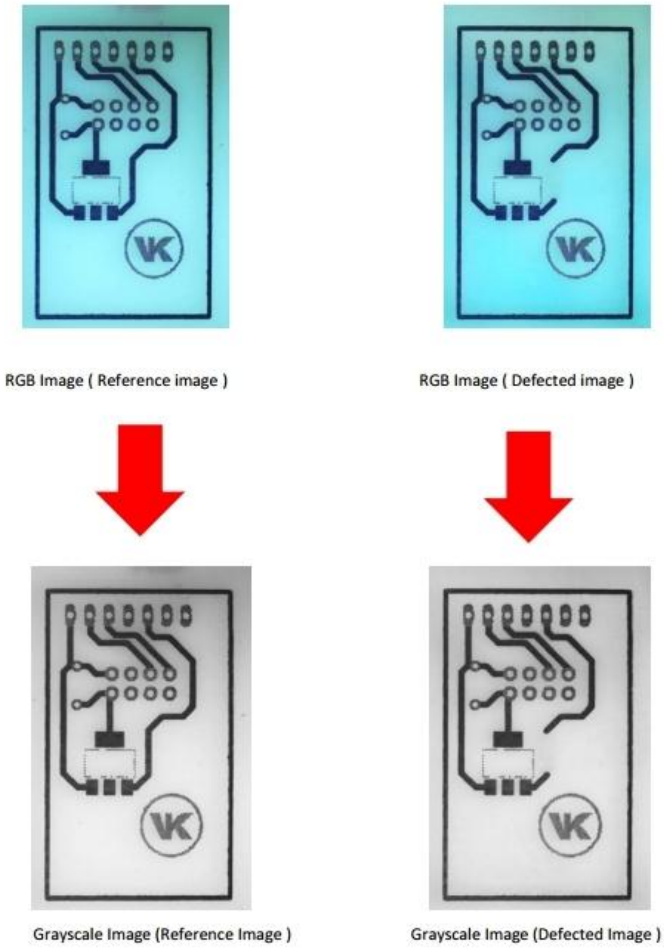
Yolo V5 is one among the best deep neural networks which focuses on object detection in images. It is easy to retrain the network on a dataset. It is a single stage object detector and has three important parts namely:

1. Model Backbone - It is used to extract important features from the input image
2. Model Neck - It is used to generate feature pyramids and helps to identify the same objects in different scales and sizes.
3. Model Head - It performs the final detection part and generates output vectors with class probabilities, objectness scores and bounding boxes.

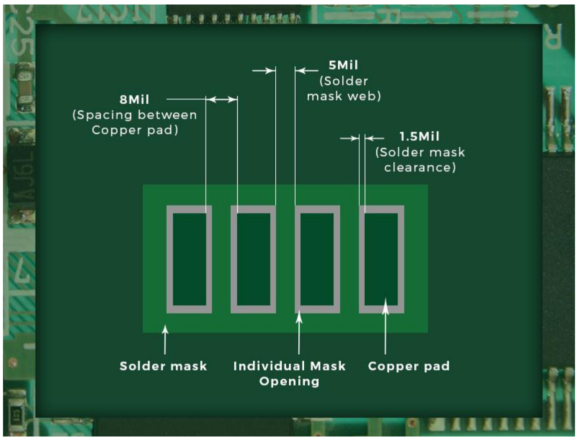
The Yolo V5 network needs a specific set up of data folders to perform efficiently. The data folders consist of two folders, one for images and the other for labels inside which there will be separate folders for train data and validation data. The images should contain unique names and the respective label should be named the same. It also has built in augmentations to help a robust model during training of data. Therefore, it is considered as one of the equipped object detection algorithms.

Manufacturing of defect free PCBs is the expectation to be met. Some of the commonly faced issues are bad light conditions, height at which the image is taken, tilt of the images. In the current scenario the detection of flaws should overcome the quality of low quality images and provide better results in prediction of defects. More the number of PCB circuit inputs given, higher is the efficiency of detection. The production of PCB is a multidisciplinary process and etching is the most crucial part as it involves removal of unwanted copper and so the detection of the flaws in the PCB design has to be done before etching. However, all the inspections are done later and if any defect is found, the PCB is no longer useful and is thrown away. Therefore the detection should be before the etching process so that the PCB design can be reprocessed. Images of the PCB design can be fed as input at every stage to avoid defects in the PCB design and improve its efficiency.

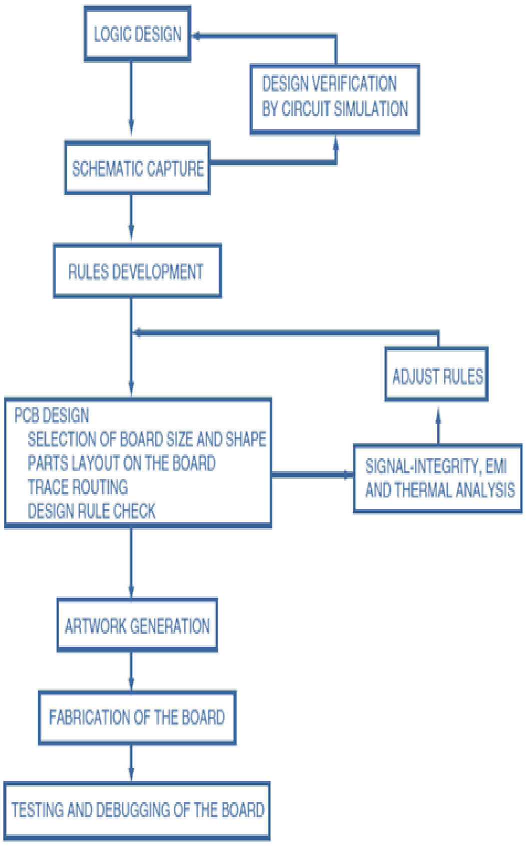
6. ALGORITHM OUTPUT



7. BASIC PCB STRUCTURE



8. DESIGN FLOW



9. CONCLUSIONS

The bare PCB is analyzed and the defects of PCB are extracted in terms of various parameters. These parameters can be taken as referential data base for further analysis to fabricate defect free PCB and can assist in making an automated system for inspection. In order to use this method in an industrial application some improvements need to be done. Future work consists of inspecting and analyzing a PCB with Surface Mounted Devices.

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