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PCB DEFECT DETECTION USING CONVOLUTIONAL AUTO ENCODERS

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Abstract- The manufacture of printed circuit boards (PCBs) is one of the most important stages in electronic development. A very small defect on a PCB can lead to serious problems in the final product. Consequently, detecting and locating these defects are essential. An approach based on denoising convolutional auto encoders were used to detect defective PCBs and to locate PCBs it is used. Denoising auto encoders take a corrupted image and attempt to recover the intact image. By training this model with defective PCBs and forcing it to repair the defective parts, this model help us not only to detect all kinds of PCB defects and locate them, but also to fix them. The defective parts can then be located by subtracting the repaired output from the input. Experimental results indicate that this model is highly accurate in detecting the defective PCBs when compared to state of the art manual methods.

Keywords – PCB, defect detection, auto encoder, denoising convolutional auto encoders

I. INTRODUCTION

Printed Circuit Board (PCB) is a collection of electronic boards that helps different electronic components connect to each other. It is used in every electronic product and with its help, the number of errors in assembling is greatly reduced [1].PCB is made of multiple sheet layers made of copperin which electronic components such as electrical resistances or capacitors are placed. Since PCBs are the first step inmanufacturing an electronic device, a simple error in them leads to huge flaws in the final product[2].Therefore, it is vitalto detect defective PCBs not only to prevent further obstacles but also to fix the errors with as low cost as possible[3].

Virtual inspection is the most important step in PCB manufacturing.PCB inspection consists of two major process: defect detection and defect classification. In once times, image processing ways were extensively used to automate these processing in PCB diligence. These ways can detect imperfect corridor in PCBs and classify them [6].Still, due to the limitations and downsides of these ways, they have replaced with other methods as machine learning method in recent times [3].Machine learning methods have attracted the attention of a variety of people from academia to industry. One of the most popular machine learning methods is neural networks, which consist of several nodes connected to each other to form a structure like the human brain. Convolutional neural network (CNN) is a special kind of neural networks that consists of several hidden layers. Auto encoder is an unsupervised neural network that tries to code inputs into a set of features andthen decode them again to achieve outputs [5].In order to classify the PCB defects, detection and classification system using a morphological image segmentation algorithm and image processing theories were used [7].To locate any defects on PCBs automatically using a wavelet-based image difference algorithm [8]. This scheme is more efficient compared to previous traditional methods. By using soft computing technique, hybrid approch were used to detect defects in PCB's and it is also classified based on these techniques [9].This approach uses an adaptive geneticalgorithm for feature selection and a neural network classifier.To tackle the problem of solder-balls occurrence in PCBs, data mining approach were used to identify these defects [10].

A Denoising Auto encoder is a modification on the auto encoder to prevent the network learning the identity function. Specifically, if the auto encoder is too big, then it can just learn the data, so the output equals the input, and does not perform any useful representation learning or dimensionality reduction. Denoising auto encoders solve this problem by corrupting the input data on purpose, adding noise or masking some of the input values.

Denoising Auto Encoders (DAE) try to achieve a good representation by changing the reconstruction criterion. Indeed, DAEs take a partially corrupted input and are trained to recover the original undistorted input. In practice, the objective of denoising auto encoders is that of cleaning the corrupted input, or denoising.

Higher level representations are relatively stable and robust to the corruption of the input. To perform denoising well, the model needs to extract features that capture useful structures in the input distribution. In other words, denoising is advocated as a training criterion for learning to extract useful features that will constitute better higher-level representations of the input.

II. PROPOSED ALGORITHM

The proposed system of the model gives you the full detail of the projects where the inputs of the normal test PCB and the defected PCB and denoising with the validation loss of about 0.0044 and with that the images are getting it to a next level of process which is encoding it to get the defected area of PCB. In this process by taking the two-output image from auto encoders changing its form from normal grayscale matrix to RGB matrix and giving it for convolution.
Here two images were taken part in the convolution so by getting the two images of normal PCB and defected PCB at the first stage the images are downloaded in the same folder of MATLAB as a grayscale image through denoising it and at the next stage we need to change its matrix to RGB to get it to again make a grayscale to make a convolution. On the second stage of convolution the grayscale image is changes into a binarized image all the matrix of image into 1's and 0's after that at the third stage extracting the highlighted area of the PCB where the circuit of the PCB needs to be highlighted and it is done. On highlighting the images of denoised PCB were convoluting it to get the amount of area which is defected and thus we get the result of our project. Many industrial products need this type of mechanism to automatically identifies the defected PCB so that it
can eliminate the problems from the final product.

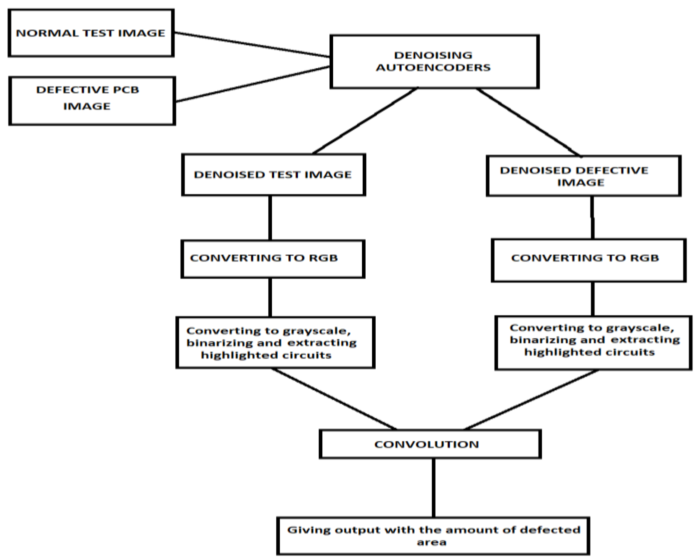

Fig 1 System flow diagram

The proposed auto encoder is trained with a dataset containing image pairs of defective and intact PCBs. We added salt-and-pepper noise to the defective.PCBs to force the auto encoder to learn better features. The output of the network is the repaired PCB. The difference rate between the input and the output determines whether the inputPCB is defective or not. Moreover, by subtracting the repairedPCB from defective input, defective parts can be located.

III .NETWORK STRUCTURE

D enoising convolution auto encoders are used in the proposed method to detect and repair defective PCBs.Denoising auto encoder is a special type of auto encoder which its inputs are noisy data, and it is forced to regenerate theintact samples by learning the features.

The designed auto encoder consists of 2 parts, encoder and decoder. Each part includes 3 layers. The encoder has 4 sub layers: Convolution layer, Batch normalization, Activation layer and Max pooling. The decoder sub layers are convulsion layers, batch normalization, and activation layer and up sampling.

The input images are 512*512 which are encoded into a vector contains 512*512 features. The decoder outputs a 512*512 images as the repaired image. The input and output of all layers are 512*512 image as the repaired image. The input and output of all layers are 512*512 vectors.

The activation function used in the network is the sigmoid activation function and Relu activation function.

It is defined as the

$$f(s)=11+e-s \rightarrow 1$$

The Relu activation function is

$$\text{Relu}(x)=\max(0, x) \rightarrow 2$$

To force the network to learn more useful features, salt-and-pepper noise is added to defective PCBs and they are used as auto encoder input. The network is forced to recover the repaired PCB from defective noisy images. In this way, it learns the main features of an intact PCB. In this transfer learning is used in order to achieve better results. At first, trained auto encoder is used to learn the features of normal PCBs. This trained model is used as the initial weights of proposed network.

IV. DETECTING DEFECTS

The trained network predicts the repaired PCB from the inputs. By subtracting the output from the input, the defective PCB is determined. The more the difference between the input and the output is, the more the PCB is defective. Structural similarity (SSIM) is used to calculate the difference. We smooth the the result of SSIM to get more accurate difference and we draw contours of the resulted image. Each contour locates a defect and by computing the sum of these contours areas, the final difference is calculated.

V. RESULT AND DISCUSSION

The Deep PCB dataset that is provided by Tang et al "One class based feature learning approach for defect detection using deep auto encoders", is used for this experiments. The dataset contains 1500 image pairs of a defective PCB with its aligned normal PCB. This dataset includes 6 kinds of defects. In this section, the proposed model is evaluated and the results are described. The network is trained with image pairs of defective and normal PCBs and also salt-and-pepper noise is added to the defective PCBs to achieve better results.

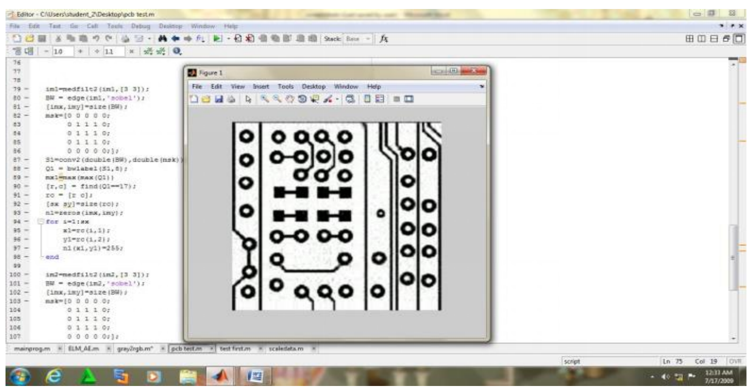

Fig 1Original test image

The dataset contains original test and original defect image are stored and it is given as the input and the result is taken for both the original test image and original defect image as the regenerated test image with validation.

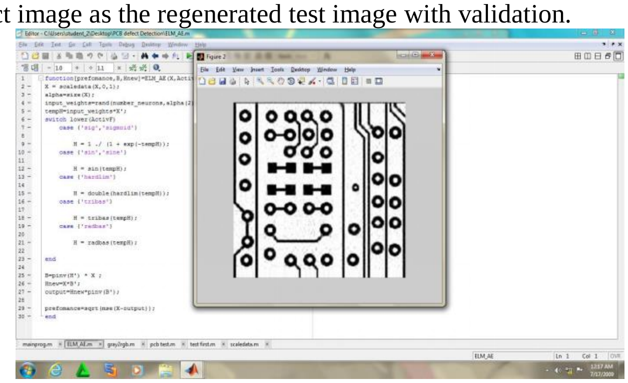

Fig 2 Original defect image

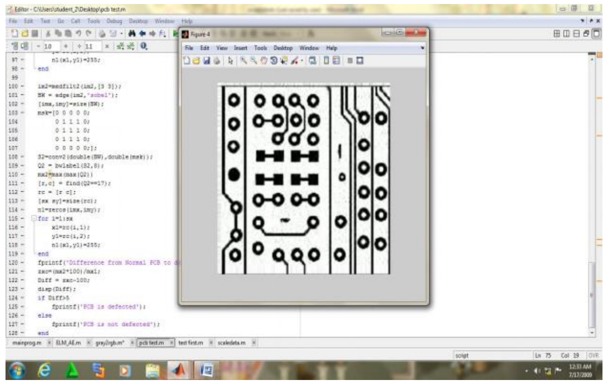

Fig 3 Regenerated test image

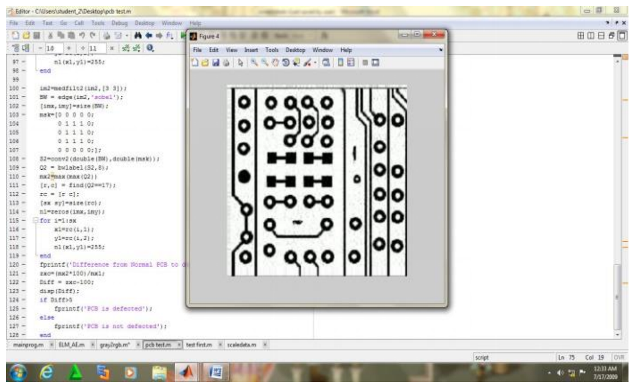

Fig 4 Regenerated defect image

Fig 1,2,3,4 shows the result of the original test image and regenerated test image and also the original defect image and regenerated defect image were obtained.

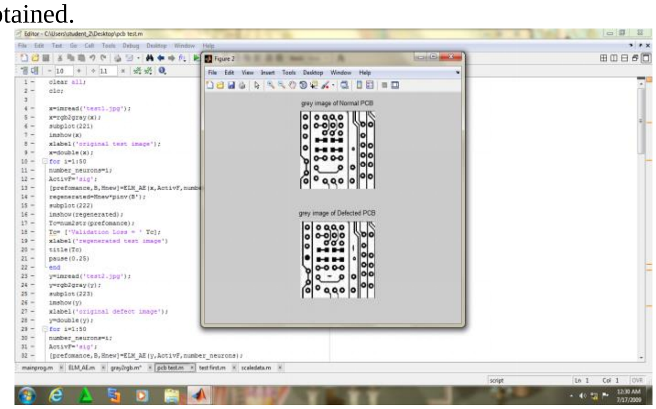

Fig 5 Grey image of normal and defected PCB

Fig 5 Greyscale image of the normal PCB and the defected PCB through denoising it and changes its matrix to RGB image. And then the RGB image is converted to greyscale image to make convolution.

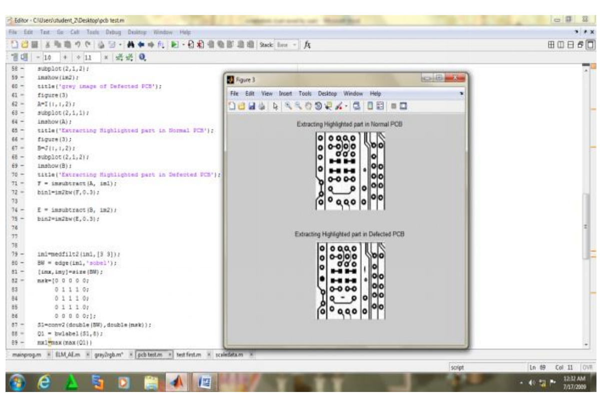

Fig 6 Extracting highlighted part in normal PCB and defected PCB

Fig.6 shows the extracting highlighted area of the PCBs, the images were convoluted to get the amount of the area of the defected PCBs.

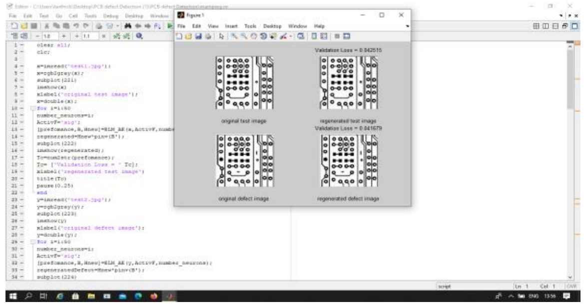

Fig. 7 Regenerated test image &Regenerated defect image with validation loss

Before training the proposed denoising auto encoder, first trained an auto encoder with only normal PCBs to learn their. Then used the weights of that network for initial weights of our proposed network which increased the accuracy of the model. The validation loss of the network is 0.041679.

CONCLUSION

PCBs play a key role in producing electronic devices and the quality of the final product depends on its PCB. Therefore, the PCB should be flawless. In this proposed a defect detection method for PCBs based on denoising auto encoders. The network was trained with the image pairs of the intact and defective PCBs. By learning the features of an intact PCB, proposed method is able to repair the input and by subtracting the input from the output, the flaws are located. The results proved the effectiveness of the proposed method. This project presented a novel approach for defect detection in PCBs, however; the proposed method can be used to detect the defects in other kinds of products such as plastic injection molding products. Moreover, the subtracting algorithm can be improved to achieve more accurate results in locating the defects.

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