Augmented Reality System to Help Train New Skilled Workers for PCB Inspection

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Abstract
Printed circuit board (PCB) inspection is one of the major requirements in electronic industry, as in the last decades, a number of innovative methods have been designed and implemented. Due to various reasons, many companies are still using skilled workers instead of fully automated systems for PCB inspection. As the training of new workers is time and recourse consuming, this paper presents an augmented reality based system, which provides an additional aid by presenting discrete information gathered from the experience of skilled workers.
Keywords: Printed Circuit Board, Augmented Reality, Computer Vision, Automated Visual Inspection.

1. Introduction

In electronic industry the demand for quality is high and the inspection of printed circuit board (PCB) is one of the most basic requirements [2]. During the last few decades, a number of new techniques and systems for PCB inspection were developed and a comprehensive survey in that matter was piblished by Huang et al. [1]. Due to the increase in computational power and of the low cost of computer vision inspection system, many companies use the automated visual system (AVI) for PCB inspection. AVI are normally tailor-made for one scenario, therefore it is normally designed and deployed at the start, making it limited if used in an environment less robust or less flexible for changes.

One can observe that a number of small and or big size companies are still using skilled workers for PCB inspection. Skilled workers are difficult to retain and requires a lot of recourses while the quality of the inspection depends on their observations and judgments [1]. A skilled worker develops a criteria in his/her mind to judge the defect, specially in the cases where the distance between soldering points or circuits pins are needed to be checked. This criterion is difficult to teach to a new worker, as it is mostly base upon the experience of the skilled worker rather than having discrete values. In this paper we are presenting an AR base application, developed for a multinational company to help the new workers to perform fast and more accurate PCB inspection.

2. Existing System

Knowledge of existing working system is very important, especially when the adjustment of that system is required. In our case, the existing working system is a vision based PCB inspection system of a well-known German company. An X-ray camera is used to acquire images in different parts of the PCB, being displayed on a monitor where a skilled worker, after inspection, approves or rejects the board. Every PCB is divided into six parts or regions of interest, thus the images of all those parts are taken and displayed to the skilled worker.

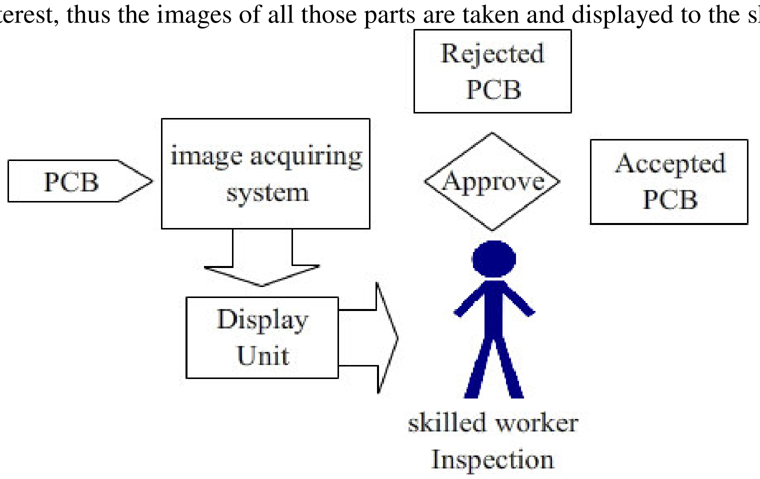


Figure 1. Block diagram of the current working system of PCB inspection

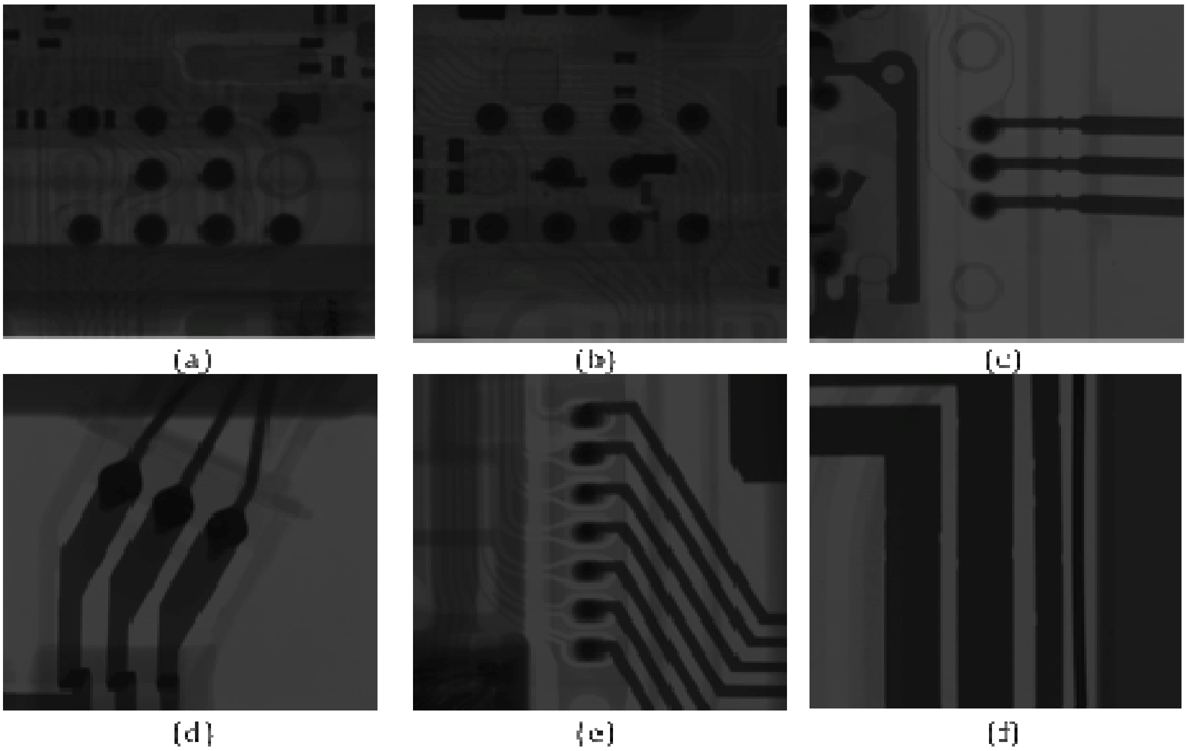


Figure 2. The six images of interest from the PCB

The inspection requirement for images in Figure 2 a) to e) are the estimated distance between soldering points, which should be correct and relatively the same on all boards, while the requirements inspection for image f) is to have a suitable distance between pins and relatively the same for all boards. There are no discrete values given, explaining what is a correct or suitable distance, therefore all the inspections are completed upon inspectors skills.

3. Proposed System

In order to simplify the process of inspection, an AR system was proposed. AR normally uses some kind of markers, identifiable objects or features in an image or video, in order align and present the information [5]. As images are taken from a static camera, in nearly static environments, the chances for variation are very low and does not requires the rotation or scaling of images. In these conditions, a histogram matching [4] will differentiate between images of different parts of PCB with very less computation, making the system aware of which kind of image is dealing with. This awareness will make possible the use of patterns for every image, as markers to align the information to be displayed.

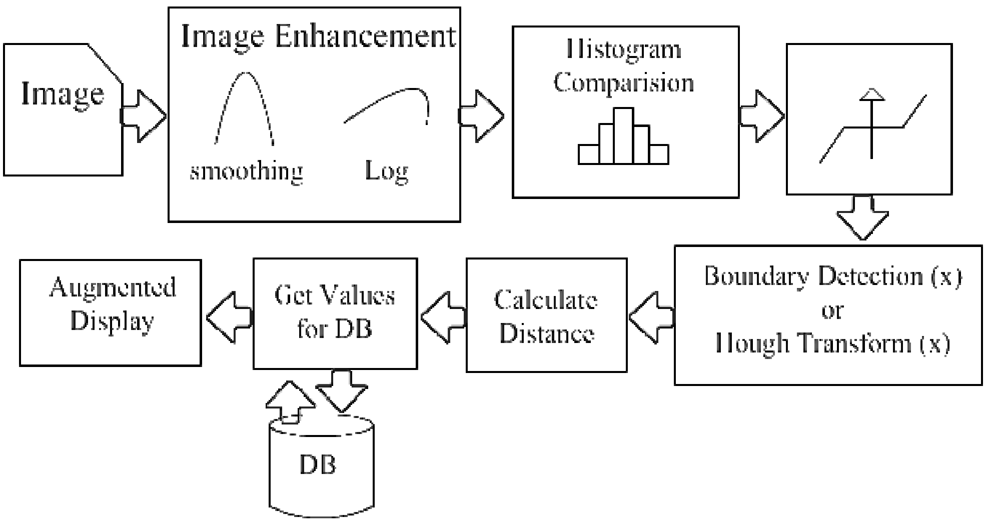


Figure 3. The block diagram of the proposed AR system

The proposed system block diagram in Figure 3 explains the workflow, as the first step enhances the image, using equation 1 and 2.

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \quad (1)$$

$$I_g = \varepsilon * \log(1 + \rho) \quad (2)$$

where ε is a multiplier factor varying from 1 to 3 and ρ represents the pixel intensity of the processed image.

The histogram matching is used to identify among the 6 types of images; if current input image is type f), then a boundary is build around every pin, using the eight-neighbor formula, else the soldering points are detected using the Hough transform [3]. After detecting the soldering points or computing the boundary, three information variables are displayed, the current values, the average of minimum values and the average of maximum values. The current value is calculated in runtime for every image, while for the f) type image, the current value is calculated using the distance between adjacent boundaries. For rest of the images, the current value is calculated by detecting the soldering points and applying the distance among all adjacent points, both in horizontal and vertical directions. The distance formula is given equation 3.

$$\partial = \sqrt{((\alpha_2 - \alpha_1))^2 - ((y_2 - y_1))^2} \quad (3)$$

Where

$\alpha_2 = x_2 - r_2$
$\alpha_1 = x_1 + r_1$

x_1, x_2 and y_1, y_2 are the center, r_1, r_2 are the radius of the respected soldering points. ∂ Represent the current value and is displayed in yellow color on the display screen. If the skill worker approves board then value of ∂ is checked with X. If $\partial > \mathrm{X}$ then ∂ is added in set κ and $\mathfrak{M}$ else ∂ is added in set κ and $\mathfrak{m}$.

Average of the set κ, $\mathfrak{m}$ and $\mathfrak{M}$ is calculated for further processing.

$$\mathrm{X} = \frac{\sum_{i=1}^{n} \kappa_i}{n} \quad (4)$$

Where 'n' is total elements in set κ

$$\mathrm{X}_{min} = \frac{\sum_{i=1}^{n} \mathfrak{m}_i}{n} \quad (5)$$

Where 'n' is total elements in set $\mathfrak{m}$

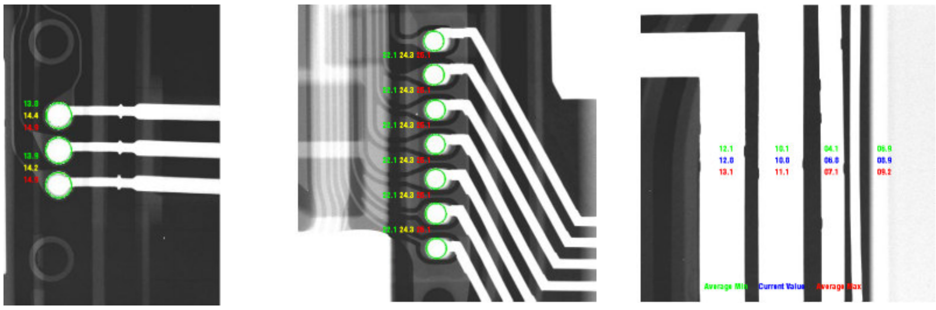
$$\mathrm{X}_{max} = \frac{\sum_{i=1}^{n} \mathfrak{M}_i}{n} \quad (6)$$

Where 'n' is total elements in set $\mathfrak{M}$.

The average of set $\mathfrak{m}$ is calculated as the *average of minimum values* denoted by X_{min} and displayed on monitor in green color. If ∂ is lower than X_{min} , then the user need to be more careful while making a decision. The average of set $\mathfrak{M}$ is called *average of maximum values,* denoted by X_{max} and displayed in red color. If ∂ is higher than X_{max}, then the user is made conscious while making a decision.

4. Results

The proposed system is using run-time and saved values to calculate and generate discrete information for the inspector, helping him to make decisions with more confidence. At the same time, the need of an experience assistant became very low. The resulting images and the corresponding information displayed are shown in Figure 4.



(d) (e) (f)

Figure 4. Resulting images of the six PCB parts with discrete information**.**

Figure 4 shows the statistical information and alignment displayed in different color, as a way to help the inspection or the training. The proposed system is working fine on a test environment; still it was never been tested in a real time scenario in industrial environment.

5. Conclusion

The AR system can help the training of new inspectors and it doesn't require many changes in the existing system. Converting the fuzzy information into discrete also helps in making fast and more accurate decisions. The proposed system uses simple and fast computer vision techniques, which not only help the AR system to identify the corresponding interest images, but also finding the markers for the alignment of objects. It will also calculate runtime information on the PCB positions, making things easier for the human inspector.

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