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Optical Imaging Based Detection of Solder Paste in Printed Circuit Board Jet-Printing Inspection

Authors : D. Heinemann, S. Schramm, S. Knabner, D. Baumgarten

Abstract : Purpose: Applying solder paste to printed circuit boards (PCB) with stencils has been the method of choice over the past years. A new method uses a jet printer to deposit tiny droplets of solder paste through an ejector mechanism onto the board. This allows for more flexible PCB layouts with smaller components. Due to the viscosity of the solder paste, air blisters can be trapped in the cartridge. This can lead to missing solder joints or deviations in the applied solder volume. Therefore, a built-in and real-time inspection of the printing process is needed to minimize uncertainties and increase the efficiency of the process by immediate correction. The objective of the current study is the design of an optimal imaging system and the development of an automatic algorithm for the detection of applied solder joints from optical from the captured images. Methods: In a first approach, a camera module connected to a microcomputer and LED strips are employed to capture images of the printed circuit board under four different illuminations (white, red, green and blue). Subsequently, an improved system including a ring light, an objective lens, and a monochromatic camera was set up to acquire higher quality images. The obtained images can be divided into three main components: the PCB itself (i.e., the background), the reflections induced by unsoldered positions or screw holes and the solder joints. Non-uniform illumination is corrected by estimating the background using a morphological opening and subtraction from the input image. Image sharpening is applied in order to prevent error pixels in the subsequent segmentation. The intensity thresholds which divide the main components are obtained from the multimodal histogram using three probability density functions. Determining the intersections delivers proper thresholds for the segmentation. Remaining edge gradients produces small error areas which are removed by another morphological opening. For quantitative analysis of the segmentation results, the dice coefficient is used. Results: The obtained PCB images show a significant gradient in all RGB channels, resulting from ambient light. Using different lightings and color channels 12 images of a single PCB are available. A visual inspection and the investigation of 27 specific points show the best differentiation between those points using a red lighting and a green color channel. Estimating two thresholds from analyzing the multimodal histogram of the corrected images and using them for segmentation precisely extracts the solder joints. The comparison of the results to manually segmented images yield high sensitivity and specificity values. Analyzing the overall result delivers a Dice coefficient of 0.89 which varies for single object segmentations between 0.96 for a good segmented solder joints and 0.25 for single negative outliers. Conclusion: Our results demonstrate that the presented optical imaging system and the developed algorithm can robustly detect solder joints on printed circuit boards. Future work will comprise a modified lighting system which allows for more precise segmentation results using structure analysis.

Keywords : printed circuit board jet-printing, inspection, segmentation, solder paste detection
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