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   RESEARCH METHODOLOGY

   RESULTS & DISCUSSION

   FINDINGS

   RECOMMENDATIONS/SUGGESTIONS

   CONCLUSIONS

   SCOPE FOR FURTHER RESEARCH

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PB FREE SOLDERING INSPECTION OF PCBA

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ABSTRACT

This paper is focused on to the PB(Lead) free soldering of printed circuit board inspection system based on image processing and pattern recognition techniques. A novel lighting method is adopted to inspect the solder fillet through which it is possible to inspect the chip with fine pins, such as electrical contact between the fixture probe and solder coated via or pad for the different type such as MCS0402AT and MCT0603AT. A gradient descent algorithm is used for the image feature map matching computing. Based on this image learning function, reflow soldering of the surface mount devices can be inspected.

KEYWORDS

Optimal Estimation, Printed Circuit Board (PCB), PB free SAC , Solder Joints, Steepest Descent Algorithm.

INTRODUCTION

With the advancement of technology of integrated circuit (IC) techniques, the electronic components become smaller and the number of IC pins has increased increase and the size of the circuit is reduced. The electronic components are embedded on to the Printed circuit boards (PCBs). The boards have to be inspected extensively with different methods. Though the components such as resistors are suitable for processing on automatic assembly systems, they are suitable for automatic soldering using wave or reflow, but still it has to be inspected to isolate the defects such as shorts, opens, over-etching, under-etching, pad size violations, and spurious metals. Although a great deal of work has been done in the area of PCB inspection, very little research addressed the inspection of solder joints. The objective of Inspection of PB free PCB is to identify typical solder joint defects on PCBs such as missing solder, cold solder, excess solder, blowholes, voids, and broken solder joints. Mismatch of the components inserted on to the PCB should also be inspected. As the electronic industry begins to focus upon tin-silver-copper family of alloy as a viable replacement for tin-lead solders, the tin-silver-copper family of alloys has earned a great deal of positive response from various industries. The best manufacturing practices for lead free SAC (tin, silver, copper) ideal temp is 650F – 700 maximum. SAC alloy produced a visual characteristic identical to cold solder fillet. It also produces an increase in wetting contact angle. Soldering lead free with a bottom pre-heater at around 150 to 200f or from a heat gun promotes much better wetting as silver has a higher melting point to achieve its liquidous phase.

Image processing and pattern recognition techniques play an important role in this area. The binary image can be drawn from the original one. By comparing the solder joint areas or the circumferences, the evaluation can be carried out. Another way is to compare the acquired image with the original one. The difference between the two images will give the result.

INSPECTION SYSTEM

The process starts with imaging the object to be inspected by a sensor (or sensors) from which visual data are collected and sent to the processor for analysis. Features representing the object are then extracted and matched to a predefined model. The feature-to-model matching process is the most common technique for detecting defects. Figure 1 gives a schematic of the inspection system. A one-dimensional line camera is used to acquire the data from the reflect mirror. In order to characterize the solder fillet, a novel lighting technique is adopted (as shown in Fig.2). There are seven LED array boards in the lighting equipment. After the camera acquires a single line, the LED array switches from one to another, i.e. changing the illuminating angle. A linear actuator will move the PCB along the x and y directions. As usual, the width of the solder fillet varies from 0.35 mm to 2.05 mm representing the pad dimensions as G,Y,X and Z as shown in Figure 3 and multiple pixels can be acquired from this area. But corresponding images acquired by the fixed or movable camera are all the same. So, if the line senor is applied and every pixel is acquired at different illuminating angles, the corresponding image will be different as shown in Fig.4. In fact, this technique carries out an image fusion procedure. Other than fusing the whole image, it combines the (pixel) lines obtained at different illumination conditions into one image. It is possible to inspect the fine pin by this technique.

FIG. 1: SCHEMATIC OF THE INSPECTION SYSTEM

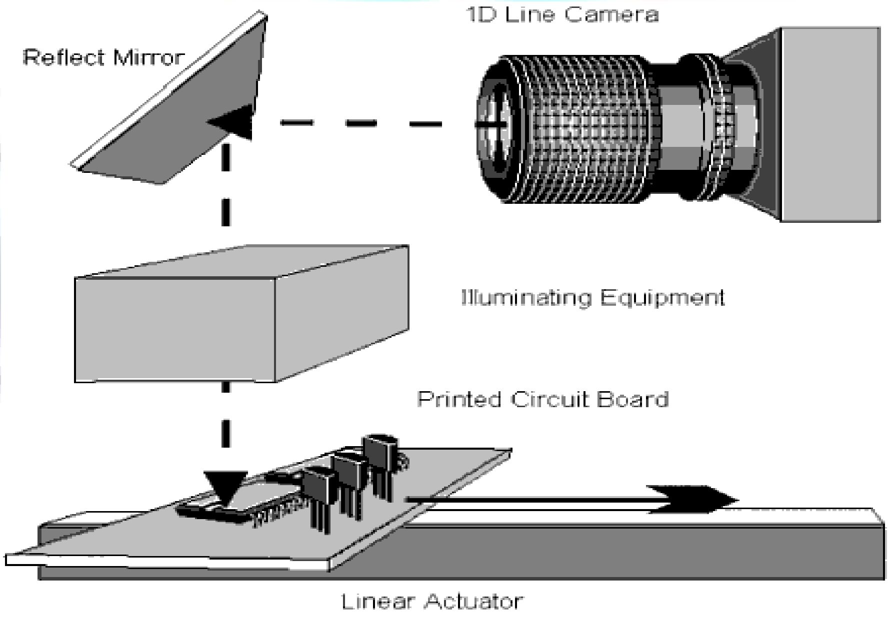


FIG. 2: THE ILLUMINATING METHOD

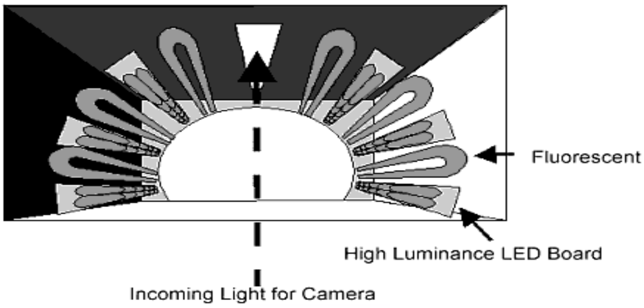


FIG. 3: THE DIFFERENT IMAGES OBTAINED AT DIFFERENT ILLUMINATING CONDITIONS

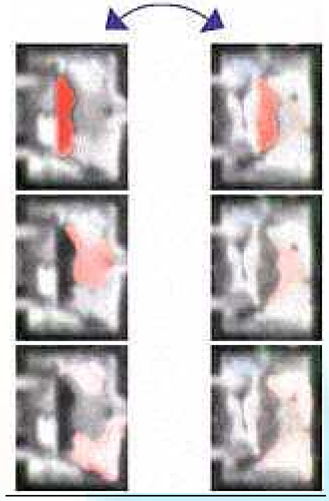


FIG. 4: THE ILLUMINATING METHOD

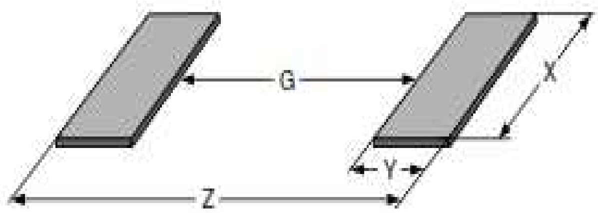


IMAGE ANALYSIS

The judgment is made based on the correlation values of the images or the comparison of the image feature maps [2,3]. Three methods are involved:

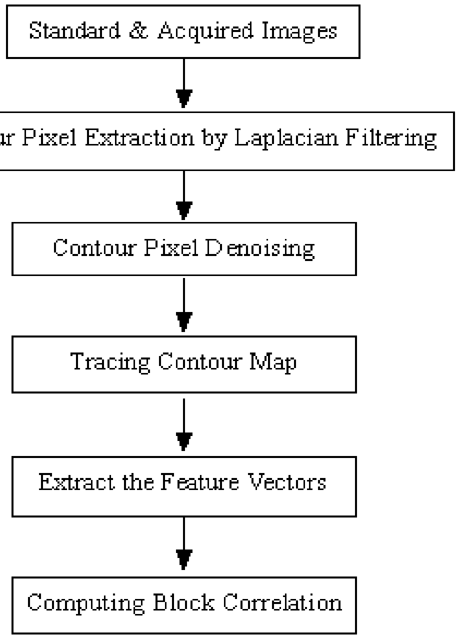
- Computing the correlation value between the standard image and the image obtained at different illuminating conditions;
- Computing the block correlation value of the acquired images; and
- Comparing the contour vector of the standard image and that of the acquired image.

For an effective computation, a so-called steepest descent algorithm is employed for the image feature map matching. And an optimal estimation procedure is carried out for the inspection of the reflow soldering of DIP. Depending on the images obtained at different illuminating conditions, the fillet correlation should be obtained. And this can be done by two steps: first, computing the correlation between the standard image and the acquired image at every illuminating angle; second, computing the fillet correlation, i.e. the product of all the correlation values obtained at the first step (as shown in formula (1)). Finally, compare the fillet correlation value with the threshold.

$$\prod_{n}^{N}(\mathrm{Corr})_n = \mathrm{FC} \qquad (1)$$

Here, $(\mathrm{Corr})_n$ means the correlation value obtained at illuminating angle n and FC stands for the fillet correlation. If the fillet correlation value is under the threshold, the fillet is regarded as abnormal. For the fillet correlation is the product of all the correlation values. The procedure of computing the block correlation is given in Fig.5. Both the standard image and acquired image are divided into blocks. The correlation values between the corresponding blocks are calculated for the evaluation. The third method mentioned above is the evaluation from the edge map. Edge maps of both the standard image and input image are extracted. The difference between these two maps can be evaluated by the rotation and translation parameters. If two points on a line (x1,y1) and (x2,y2) correspond to the other two points (X1,Y1) and (X2,Y2), the rotation and the translation can be computed by formula (2) and (3) respectively. The threshold value $\square_s$ and a_s are firstly set up by the operator.

FIG. 5: THE EVALUATION METHOD BASED ON BLOCK CORRELATION



$$\theta = \left\| \arctan\frac{Y_1 - y_1}{X_1 - x_1} - \arctan\frac{Y_2 - y_2}{X_2 - x_2} \right\| \quad (2)$$

$$d = \sqrt{\left(\frac{x_1 + x_2}{2} - \frac{X_1 + X_2}{2}\right)^2 + \left(\frac{y_1 + y_2}{2} - \frac{Y_1 + Y_2}{2}\right)^2} \quad (3)$$

The methods introduced above are the basic ones. To improve the computing efficiency, the following methods are adopted:

STEEPEST DESCENT ALGORITHM (SDA)

To apply the SDA to 2D image, the two steps below should be followed: The minimum thinning out value is assigned zero. The initialization of the thinning out value is assigned K. D is assigned to the initial search range. There is:

$$-D < dx < D\,,\; -D < dy < D \quad (dx, dy):$$

nearby search vector

Firstly, the thinned-out standard image and the acquired one are compared by the evaluation function around the following area. And the maximum value is searched.

$$\begin{matrix} (-D/2, -D/2), & (0, -D/2), & (+D/2, -D/2) \\ (-D/2, 0), & (0,0), & (+D/2, 0) \\ (-D/2, +D/2), & (-D/2, +D/2), & (+D/2, +D/2) \end{matrix}$$

Secondly, decrease the thinning out value to the half, i.e. D= D/2. The iterative operation is carried out until D= 1. By this method, a logarithmic decrease on computation can be achieved.

In the above example, the eight pixels around the center one are involved in computing. In practical application, the number of the pixels around can be added or removed basing on the complexity of the image content. And the initial thinning out value can also be adjusted for different images. If the correlation value is less than the threshold, the computation near that block should be carried out again with the different initial thinning out values and different neighbors.

OPTIMAL ESTIMATION

It is really a time-consuming work to extract a DIP image from a 10000□10000 pixel image. The methods include:

1. extracting the feature pixels of the DIP image;
2. extracting the parts with high cross-correlation value, which are achieved by a method similar to SDA.

The matching operation will be applied to the feature images. The selection of A and B will finally maximize the matching result. The (4) will ultimately converge to the minimum value.

$$S + \alpha R / N \quad (4)$$

where S is the reduction component; □ is the mortgage parameter; N is the iteration times; and R is the random number.

CONCLUSION

In this paper, a Pb free PCB inspection system based on optical-electronic technique is described. The novel illuminating method is adopted to inspect the solder fillet by computing the fillet correlation. The techniques for effectively analyzing the image are developed: the steepest descent algorithm and optimal estimation.

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