Enhancement Machine Vision System Using Morphology Technique

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Abstract

Now a day the electronics circuit board has a small size according to all components are very tiny size. Thus, to inspect the failure alignment for quality control on circuit board, it is required a machine vision. This article investigates an image processing technique to inspect the quality of chip resistors for PCB industrial based on the inspection machine image. The morphological closing and opening operations are performed to extract the chip resistor area and performed the extrema regions to evaluate the alignment of each chip resistor. This article provides two technique to compare in condition of the classify image. The results show that it provides the 92% of accuracy. This technique can be adjusted and exploited in the PCB inspection.

Keywords: morphology technique, machine vision, PCB industrial

1. Introduction

Recently, the PCB electronics board is requires the small size of component, so that called chip component, for reducing the size of the board. To produce that chip, the electronics industrial needs a high quality control for failure precision which uses machine and human vision. Therefore, the quality control of electronics component process, especially the basic chip component such as resistor, is important to decide or inspect the products in order to the precision and quality of products. The inspection process will make more reliability to accept the products. Therefore, this research is focus to identify misalignment of chip resistor using the image processing techniques to instead of human vision for the quality guarantee.

In [1] presents a fingerprint segmentation technique based on morphological processing which use a part of morphological closing and opening operations. It is performed to extract the foreground from the image. The results show that the average classification error rates are much less than other segmentation methods. In [2] presents an extend closing operation in morphology and its application in image processing in the post-earthquake on UAV aerial image which filling up holes and changing image size by one step. The results show that the expansion has certain theory significance and practical value. In [3] presents the multi-scale maximally stable extrema regions for object recognition. It improves the performance in large scale change situation with MMSER which is maximally stable both in the image space and the scale space. It is proposed by defining a criterion to evaluate the stability of extrema regions in scale space. The result shows that it has stable boundary and can describe the shape of the local features well. In [4] presents the pedestrian detection based on maximally stable extrema regions. The extraction of the regions is based on MSER, the dispersions measure is used to distinguish between humans and artificial objects. The results show that it achieves a detection rate of 90%. In [5] presents an Area of Interest (AOI) algorithm for PCB based on feature extraction. The place, shape, and logical features of the solder joints of the chip components are extracted, and AOI algorithm is developed on the basis of the features. The defects of solder and component can be identified.
properly during the inspection of 167 pieces of PCBs which had 187,040 chip components in all. This algorithm can inspect PCB’s defects effectively, only one defect was undetected.

Those researches are interested to explore the image processing for PCB industrial which there is an advantage and disadvantage. This article is also interested to apply the image processing for PCB industrial, especially inspection the failed part. This article investigates an image processing technique to inspect the quality of chip resistors based on the inspection machine image. The morphological closing and opening operations are performed to extract the chip resistor area and performed the extrema regions to evaluate the alignment of each chip resistor. Therefore this technique can be analyze and identify the defects of chip resistors in misalignment which is important and useful in the electronics industrial. Section II is introduces the morphology methods. The experiments and results are explained in section III and IV respectively. The conclusion is also briefed in section V.

2. Morphology

2.1 Mathematical Morphology

Mathematical morphology is the mathematical approach of image analysis that providing a quantitative description of geometrical structures based on set theory. The most basic morphological operators are erosion, dilation, opening and closing. The operators and their combinations are particularly useful for the analysis and processing of binary images and common usages including image segmentation, feature extraction, edge detection, stitching, image enhancement and recover.

(a) Dilation

It is one of the important operators in morphology. Dilation process can fill up holes in image and halite the targets that are concerned. Dilation operator expanded each position \( x \) in \( X \) to \( S[x] \), and is denoted as \( X \oplus S \), in the form of set, it is defined as

\[
X \oplus S = \{ x | S[x] \cap x \neq \emptyset \}
\]  

(1)

(b) Erosion

It is one of the basic operators in morphology. Erosion of an image can be described as: Given a target image \( X \) and a structuring element \( S \), translate \( S \) on the image. For each current position \( x \), \( S[x] \) have three possible states.

1. \( S[x] \subseteq X \)
2. \( S[x] \subseteq X' \)
3. both \( S[x] \cap X \) and \( S[x] \cap X' \) are not null.

In the first case, \( S[x] \) has the maximum correlation with \( X \), in the second case \( S[x] \) has no correlation with \( X \) at all, in the third case \( S[x] \) only partially correlated with \( X \). Therefore, all the pixels that satisfy case (1) construct the set of maximum correlation pixels. We called the set as erosion of \( X \) by \( S \), denoted \( X \ominus S \). Expressed in the view of set, it can be defined as

\[
X \ominus S = \{ x | S[x] \subseteq X \}
\]  

(2)

(c) Closing Operation

Based on the two fundamental operations of erosion and dilation, we can construct morphological operation group, which is composed of set operations and combinations of operations of erosion and dilation. Two most important transformation operations are opening and closing.

Accordingly, the closing of \( X \) by structuring element \( S \), denoted \( X \bullet S \), is defined as

\[
X \bullet S = (X \oplus S) \ominus S
\]  

(3)

\( X \bullet S \) can be regarded as to recover dilation image of \( X \) by \( S(X \oplus S) \) using erosion by \( S \). For dilation and erosion are dual operations. We can learn that

\[
(X' \ominus S)' = X \bullet S
\]  

(4)

\[
(X' \bullet S)' = X \ominus S
\]  

(5)

(d) Opening Operation

The opening of \( X \) by structuring element \( S \), denoted \( X \circ S \), is defined as

\[
X \circ S = (X \ominus S) \oplus S
\]  

(6)

\( X \circ S \) can be regarded as to recover erosion image of \( X \) by \( S(X \ominus S) \) using dilation by \( S \). However, the recovering process is not lossless, which means the transformed image of \( X \) by opening operation, mostly not the same with \( X \).
2.2 Region Properties in Extrema Shape

In the 2-D case, the region is specified in 8-by-2 matrix as extrema points. Each row of the matrix contains the x- and y-coordinates of one of the points. The vector format is shown as

Fig 1. Illustrates the extrema

3. Experiment

The flow of chip resistor alignment inspection is shown in Fig 2

The input images are provided from the inspection machine Figure (3a). The machine is set height of CCD camera is 10 cm. Accuracy of pixel is 140 x 88. There are 21 pictures of faulty chip resistor alignment and 79 pictures of good chip resistor alignment that uses as input images.

Firstly, the original image is converted into a gray scale and binary labeling by threshold $T$. Figure 3(a) shows color image.

$$F(x, y) = \{(x, y)|1 \leq x \leq M, 1 \leq y \leq N\}$$ (7)

$F(x, y)$ is gray level of current pixel.

$M, N$ are size and range coordinate pixel of 2D image.

For threshold $T$ is defined by

$$T = \overline{F} - \sigma - C$$ (8)

Where $\overline{F}$ is mean value of gray level from $F(x, y)$.

And $\overline{F}$ is defined by

$$\overline{F} = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} F(x, y)$$ (9)

$\sigma$ is standard deviation of $F(x, y)$. Defined by

$$\sigma = \sqrt{\frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} (F(x, y) - \overline{F})^2}$$ (10)

$C$ is constant of contrast level, used 55.

From threshold $T$, conversion of input image is defined by

$$F(x, y) = \begin{cases} 0 & \text{if } F(x, y) \leq T \\ 255 & \text{if } F(x, y) > T \end{cases}$$ (11)

From equation (5), $F(x, y)$ is converted to black and white defined by black pixels = 0 and white pixels = 255 in gray scale. Then $F(x, y)$ is converted to binary data, as shown in Figure 3(b)

Secondly, Closing and Opening morphology (COF) can be used to remove the detected pepper noise consists of one closing and one opening, defined as follows;

$$COF(f) = (f \ast b_1) \circ b_2$$ (12)
COF Filters are combinations of closing and opening operators and perform efficiently to remove the corresponding impulse noise as shown in Figure 3(c).

![Image](a) Original image. (b) Binary image (c) COF result. (d) MaxArea result. (e) Subtraction for Extrema

Fig 3. (a) Original image. (b) Binary image (c) COF result. (d) MaxArea result. (e) Subtraction for Extrema

From Fig 3(c) is then located the maximum of white area which noticed to be the chip resistor area location. The result is shown in Fig 3(d).

Finally, for analyze the alignment of chip resistors. This research has proposed 2 techniques to determine.

The 1st technique, from Figure 3(d) the chip resistor area is determined top-left and bottom-left in the extrema points then the 2 points is measured in the distance of x-coordinates.

The 2nd technique, added the Extrema Subtraction technique to reduced errors and accurate measured in the process which added before determined top-left and bottom-left in the extrema points and then the 2 points is measured in the distance of x-coordinates.

### 4. Results

The method proposed in this research is able to detect chip resistors misalignment. The 100 data image size 140 x 88, which are exported from the machine in electronics industry within 21 pictures of faulty chip resistor alignment and 79 pictures of good chip resistor alignment, are used as input data set. The chip resistors alignment result are shown in Table 1:

<table>
<thead>
<tr>
<th>Decidable Distance (Pixel)</th>
<th>1stTechniques (images)</th>
<th>2ndTechniques (images)</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 - 32</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>32 - 36</td>
<td>63</td>
<td>60</td>
</tr>
<tr>
<td>37 - 41</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>42 - 46</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td>47 - 51</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Accuracy (%)</td>
<td>84</td>
<td>92</td>
</tr>
</tbody>
</table>

Table 1 shows the comparison of the proposed techniques. The 1st technique provides the accuracy 84%. The failure image is amiss determined in COF process in order to the image is incomplete as shown in Fig 4.

![Image](a) COF (b) MaxArea

Fig 4. Failure image from 1st technique

The 2nd technique provides the accuracy 92%. However, some failures are occurred in some areas that have the similar features with the chip resistor such as a shadow of image, brightness and darkness from machine setting. Also the blur chip resistor image is one of the fail reasons as well. The failure is shown as Fig 5.

![Image](a) Maxarea (b) Subtract Extrema

Fig 5. Failure image from 2nd technique

### 5. Conclusions

This article presents a technique to inspect the resistor image from Inspection Machine in electronic industrial. Firstly, the original image is converted to black and white in gray scale using threshold calculation. Then the black and white image is converted to binary data. Secondly, the binary labeling sequence is removed the detected pepper...
noise by COF morphology. Thirdly, the initial max area of the image is determined to get the resistor area. Then, the subtraction technique is used to customize the resistor area before measured distance in the extrema region property of x-coordinates in top-left and bottom-left regions. This technique can be developed for detection the defect of resistor misalignment. The result of judgment for normal and abnormal resistor alignment refers with SMT Quality Standard Acceptable. Finally, the judgment of normal or abnormal resistor alignment is classified. The experiments results show that these techniques can provide 92% efficiency for indicate alignment in the normal or abnormal resistor chip.

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