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A method for pose and type verification of resistor

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Abstract

This paper proposes a method for verifying the pose and the type of different resistors mounted on a PCB. First, the pose of the resistor on the PCB is determined and missing resistors are detected by shape_based template matching. Then, the type of the resistor is extracted and compared to the known reference type by edge_based template matching. Finally, six types of resistors have been verified on 120 resistor images. Experiments have shown that the shape_based template can be used to determine the pose of the resistor even if it appears rotated and scaled. The proposed method can achieve the accuracy of 100% and average recognition time of 0.15*s*.

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Keywords: Pcb; Resistor Pose; Resistor type; Shape template matching; Edge template matching

1. Introduction

Automated inspection of surface mount PCB boards is a requirement to assure quality and to reduce manufacturing scrap costs and rework. Consequently, a wide range of defect detecting techniques and algorithms have been reported and implemented in Automated visual inspection (AVI systems) in the past decade [1-8]. Sundaraj, Kenneth [1] use color background subtraction to detect missing and misalignment defects of PCB boards. Leta, Fabiana R[5]. use connectivity and image correlation detects component errors, like absence, change, and wrong position. Crispin, A.J[2] uses the normalized cross correlation (NCC) template-matching approach and a genetic algorithm to locate multiple PCB components. Wu

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Chun-Ho[9] complete components placement inspection on printed circuit boards using a particle swarm optimization approach. Du-Ming used Eigen value to inspect the defects on PCB[6]. One of the main challenges for surface mount device inspection is component placement inspection. Component placement errors such as missing, misaligned or incorrectly rotated components are a major cause of defects and need to be detected before and after the solder reflow process. Generally, there are three main approaches: referential, non-referential and hybrid. The referential techniques perform a PCB comparison with a standard image, stored in an image database. Any difference between the model and the inspected board is reported. The non-referential methods verify the board based on the design specification data. In this case, each printed board is analyzed, according to the available data. And finally, the hybrid systems use referential and non-referential techniques to analyze PCB. Unfortunately, the turn-over rate for PCB inspection is very crucial in the electronic industry. Current AVI[7] systems spend too much time inspecting PCBs.

This paper proposed a method for verifying the pose and the type of different resistors mounted on a PCB by shape_based template matching. Our solution is targeted for missing and misalignment defects of SMT devices in a PCB. Section 2 of the paper describes the illumination scheme. Section 3 discusses Shape-model template and determines resistor's position, its orientation, and two scaling factors. In Section 4, model image of resistor330Ω is presented and the type of resistor is determined. Section 5 discusses the application of approaches developed and results obtained. Finally conclusions are drawn.

2. Image Acquisition

The goal of illumination in machine vision is to make the important features (surface character) of the resistor visible and suppress undesired features. To do so, good light and illumination is much crucial. To prevent specula reflections in the images, we use a diffuse bright-front light illumination for the acquisition of the PCBs, as shown in Fig.1.

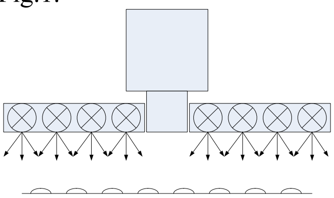

Fig.1 Diffuse bright-front light illumination

3. Pose determining

All resistors have a rectangular shape. However, the size of the resistors as well as the aspect ratio of their sides are not identical. Consequently, determining the pose of the resistor implies determining its position, its orientation, and two scaling factors, which represent the size as well as the aspect ratio. In this paper, we determined the pose using shape_based template matching.

3.1. Shape-model template

Firstly, we create an artifical template image of a generic resistor with average size and average aspect ratio. For this, we generate a rectangular contour that represents the boundary of an average resistor. Then, the contour is painted into an empty image. Consequently, the gray value of a pixel depends on the fraction by which the pixel is covered by the rectangle. For example, if only half of the pixel is covered, the gray value is set to the mean gray value of the background and rectangle. An average resistor image and the corresponding template image is shown in Fig.2. After this, a shape model is created from the template image by the following operations:

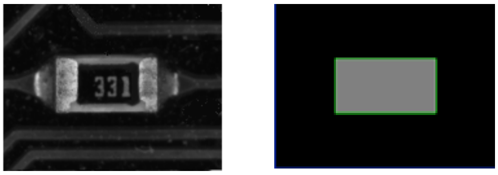

Fig.2 (a) Average resistor image: (b) Artificial template image

- Angletol=rad(5)
- Scaletol=0.1
- Create_Shape_Model(ModelImageGeneric, 3, -Angletol, 2.0* Angletol, Scaletol, 1.0+ Scaletol,
- Scaletol, 1.0+ Scaletol,)

In this application, it can be assumed that the PCB is aligned horizontally and that the resistors are mounted on the board with an angle tolerance of $\pm 5^{\circ}$. Furthermore, the length of the resistor's sides may vary by $\pm 10\%$ with respect to the average values. MeanModeHeight and MeanModeWidth. The shape model of the generic resistor is created accordingly by passing the corresponding tolerance values. The model can be used to determine the pose of the resistor in the online phase even if it rotated and scaled.

3.2. Shape_based template matching

Let us call the edge points in the template T and the edge points in the image E. Then, the Hausdorff distance of the two point sets is given by

$$H(T,E) = \max(h(T,E), h(E,T)) \quad (1)$$

Where, $$h(T,E) = \max_{t \in T} \min_{e \in E} \|t - e\| \quad (2)$$

And $h(E,T)$ is defined symmetrically. Hence, the Hausdorff distance consists of determining the maximum of two distances: the maximum distance of the template edges to the closest image edges, and the maximum distance of the image edges to the closest template edges. It is immediately clear that, to achieve a low overall distance, every template edge point must be close to an image edge point and vice versa.

4. Type determining

Determining the type of the resistor can be solved by means of the printed characters on top of the resistor. For this, we create two additional model representations, on for the print "331" on the 330 Ω resistor and one for the print '1R1'' on the 1.1 Ω resistor. In the online phase, the best matching model is assumed to represent the present resistor type. If none of the two models can be found in the online phase, the resistor type is set to 'unknown'. In the following, the model creation is described for the 330 Ω resistor. The model creation for other resistors is performed in the same manner. Its show the type of resistor that we want to detect: 330 Ω. To ease the future use of new resistor types, the model generation process is done automatically. First, the pose of the resistor in the model image is determined by the generic resistor model generated in section 3.1.

The resulting pose parameters refer to the reference point of the generic model. The reference point is the center of gravity of the domain of the model image. Since the domain of the model image comprises the whole image, the reference point is simply the center of the resistor, and hence the center of the resistor. Consequently, the pose of the generic model can be used to generate a rectangular region of interest that contains the print on the resistor. For this, we assume that the print is contained within a rectangle that has the same position and orientation as the resistor but only half of its side lengths.

Fig.3 Model image of resistor 330 Ω

The domain of the model image is reduced to the generated rectangle. Fig3. Shows the model image, the border of the found resistor, and the generated rectangle. Because the size and the aspect ratio of the print are constant in all images, this time it is sufficient to create a model that allows only rotated instances of the print to be found. Note, however, that the model is created within the full angle 360°. The reason for this is that the resistors might be mounted not only in the reference orientation shown in Fig.3. But also rotated by 180°. Note that the print on the resistor in both model images should appear at an average orientation. If this cannot be guaranteed, the model image must be rectified before creating the model.

In the online phase, we use the generated models to verify the pose and type of the resistors. To verify the pose, the generic resistor model is used. It is searched in the same pose range in which it was created.

If the model cannot be found, we assume that the resistor is missing on the board. Otherwise, we proceed with the type verification by using the two models that represent the prints on the resistors. Otherwise, we proceed with the type verification by using the two models that represent the prints on the resistors. Since we know the pose of the resistor, we can restrict the research to an appropriate image region. The region must contain the reference point of the model. Because the position of the print does not vary much with respect to the outline of the resistor,, a relatively small region is sufficient. In this paper, the region is set to a rectangle the side lengths of which are a quarter of the resistor's side lengths. Finally, the models of the prints are searched in the reduced image domain.

As mentioned above, the resistors may be mounted in the two orientation 0° and 180°. Consequently, we do not need to search the prints in the full range of 360°. In contrast, each model is only searched in the two angle range $[-Angletol, Angletol]$ and $[\pi - Angletol, \pi + Angletol]$. The multiple models can be searched simultaneously. Therefore, altogether four model handles are passed to find_models: each of the two models is passed twice, once for each angle range. If no match was found, we assume that the resistor type is 'unknown'. Otherwise, the resistor type can be computed based on the returned index.

5. Experimental results and analysis

In this paper, resistor images are acquired by Vision Acquisition Express VI, image acquisition card-PCI-1409, Smart camera NI1744 and fittest light. We had used the following environments for the time analysis: Pentium 4.30GHz, 256MB RAM. There are 20 resistor images of every resistor types. These images contain small variations of the resistor location. Tab.1 shows all resistors verification results. It can achieve the accuracy of 100% and average recognition time of 0.15*s*.

Table.1 Resistor verification results

Resistor Print	Number	Angle	Scale	Pose	Resistor Type(Ω)	Time(s)

1	331	20	OK	OK	OK	330	0.15
2	471	20	OK	OK	OK	470	0.16
3	512	20	OK	OK	OK	5.1K	0.17
4	622	20	OK	OK	OK	6.2K	0.13
5	1R1	20	OK	OK	OK	1.1	0.16
6	105	20	OK	OK	OK	1M	0.13

6. Conclusion

This paper proposed a method for verifying the pose and the type of different resistors mounted on a PCB. The shape_based template can be used to determine the pose of the resistor even if it appears rotated and scaled. Furthermore, multiple models can be searched simultaneously. Experimental results have shown that the proposed method works better in terms of computing time and accuracy.

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References

[1]Sundaraj, Kenneth, PCB inspection for missing or misaligned components using background subtraction, WSEAS Transactions on Information Science and Applications, 6(5): 778-787, 2009.

[2]Crispin, A.J.1; Rankov, V., Automated inspection of PCB components using a genetic algorithm template-matching approach, International Journal of Advanced Manufacturing Technology, 35(3-4):293-300, December 2007.

[3]Valentin, Muresan Marius1; Dan, Pitica1; Gabriel, Chindris, Automated optical inspection tool using the LPKF PCB mechanical prototyping machine. In Proceedings of 2008 2nd Electronics Systemintegration Technology Conference, ESTC, pages 1359-1362, 2008.

[4]Shun-Fa Hwang,Jhih-Te Horn and Hou-Jiun Wang. Strain measurement of SU-8 photoresist by a digital image correlation method with a hybrid genetic algorithm.Optics and Lasers in Eng., 46(3):281-289,2008.

[5]Leta, Fabiana R.1; Feliciano, Flávio F, Computational system to detect defects in mounted and bare PCB based on connectivity and image correlation., In Proceedings of the15th International Conference on Systems, Signals and Image Processing, pages 331-334, 2008.

[6]F.Lagattu;F.Bridier;P Villechaise and J Brillaud, Inplane strain measurements on a microscopic scale by coupling digital image correlation and an in situ SEM technique digital image correlation, Materials Characterization, 56:10–18,2006.

[7]Carsten steger,Markus Ulrich,Christian Wiedemann, Machine Vision Algorithms and Application ,Wiley-VCH,2008.

[8]Cho, Han-Jin1; Park, Tae-Hyoung,Wavelet transform based image template matching for automatic component inspection, International Journal of Advanced Manufacturing Technology, 50(9-12): 1033-1039, October 2010.

[9]Wu, Chun-Ho; Wang, Da-Zhi; Ip, Andrew; Wang, Ding-Wei; Chan, Ching-Yuen; Wang, Hong-Feng. A particle swarm optimization approach for components placement inspection on printed circuit boards .Journal of Intelligent Manufacturing, 20(5):535-549, October 2009.