A Computer Vision System Applied to The Recognition of Different Capacitors

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Abstract. In this paper, we establish an automation system based on computer vision for the identification of capacitors with different capacitances. The images of capacitors on the industrial assembly line are obtained in real time by using a CCD industrial camera. Then, the obtained images based on RGB model are transformed into HSI color format to avoid the effect of environmental brightness. According to the calculated characteristic hue and saturation values, the established automation system could accurately and effectively identify the capacitances of the capacitors by colors. The identification results would provide accurate information for subsequent robot arm recognition, location, collection, and other operations. By applying to the industrial assembly line, this computer vision system could greatly improve the automation level and product quality of industrial production.

1. Introduction
Capacitor, a passive component, is one of the most important common electrical devices in circuit design. This device plays a significant role in high speed circuit, whose main functions are obstructing direct current, coupling, bypass decoupling, smoothing, temperature compensation, timekeeping, tuning, rectification, and energy storage. In order to easily distinguish the capacitances, the capacitors vary in different colors. For instance, blue capacitors carry 5pF, red 20pF, and yellow 40pF. During the processing of electronic packaging, the capacitors are usually installed by mechanical arms. However, selection faults may occur during the installation procedure without effective identification. The caprice of the production genres has deprived the human visual identification of the adaptation to the development of the production. Not only cannot the human visual identification secure the efficiency of the production promptly, but also it may generate some faults of recognition. In order to avoid installing errors and select the correct capacitors, the appropriate approach of identification is urgent to be applied to mechanical arms to identify the types and capacitances.

Among all the existing methods, computer vision is one of the most effective methods for the identification of objects. By computer vision, it converts the objects into figure information afterwards transformed into a specific processing system to become the digital information, which enables the mechanical arm identify the objects with different colors and shapes. Compared with human visual identification, computer vision exhibits many salient merits. Firstly, as the computer vision system works steadily regardless of the external influence, it could greatly improve the flexibility and the level of automation of the production. Also, since it avoids the shortcomings of human visual identification and run under the high working intensity, it would enhance the quality and the stability of the task. In addition, the computer vision system is operated easily, which could be put on production without the investment of a large quantity of sophisticated instruments and process various.
tasks simultaneously without training. Therefore, this technology has achieved great success in many fields. For example, a spectrum selection method based on SNR was proposed by Z. Jia and his coworkers to obtain clear images of large hot forging [1]. S. Kang and his colleagues introduced a system, which can recognize the best object from randomized target candidates based on stereo vision and estimate the position and orientation of the object [2]. C. Jian et al. developed an improved fuzzy c-means cluster algorithm to solve the problem of segmentation defects with fuzzy grey boundaries from a noisy MPSG image [3]. By applying to the industrial assembly line, this computer vision system could greatly improve the automation level and product quality of industrial production.

In this study, we establish an automation system based on computer vision for the identification of capacitors with different capacitances. The images of capacitors on the industrial assembly line are obtained in real time by using a CCD industrial camera. Then, the obtained images based on RGB model are transformed into HSI color format, transformed from RGB, to avoid the effect of environmental brightness (H. Liu and Y. Men, 2011). According to the calculated characteristic hue and saturation values, the established computer vision system could accurately and effectively identify the capacitances of the capacitors by colors. The results would provide accurate identification and judgment for subsequent robot arm recognition, location, collection, and other operations.

2. Experimental Setup

Fig. 1 shows the identification procedure of the capacitors with different capacitances. The identification procedure mainly includes seven steps. Firstly, a CCD industrial color camera is applied to collect the images of the capacitors in real time on the industrial assembly line. The CCD industrial color camera has 2048×1536 pixels at a frame rate of 12 fps, which is suitable for object inspection in high-speed automation with very short exposure times. Normally, the images obtained from the CCD industrial camera are based on the RGB color model. However, the calculated RGB values of images are usually different, which greatly effects by the light intensity of the shooting location in actual industrial conditions. In order to reduce the effect of environmental brightness, the obtained images from the CCD industrial camera based on RGB model are converted into HSI color format [4]. According to the obtained hue and saturation values, the characteristic of capacitors with different capacitances colors could be determined. Then, the corresponding threshold of the hue and saturation for different capacitors is set, respectively. According to the threshold, the image segmentation from the hue and saturation diagram is carried out. Finally, the capacitors with different capacitances could
be identified and determined. The identification results would provide accurate information for subsequent robot arm recognition, location, collection, and other operations.

3. Results and discussion
In our experiments, three capacitors with different capacitances distinguished by colors were selected, as shown in Figure 2. Normally, the images obtained by the industrial CCD camera are based on the RGB color model. By analyzing the obtained images, the RGB values of each image could be calculated. However, the calculated RGB values of images are usually different, which greatly affects by the light intensity of the shooting location in actual industrial conditions. Therefore, the illumination situation would greatly affect the recognition results in RGB color format. As for the HSI model, only the V value represents the brightness, and the H and S values are little affected by the brightness. In order to minimize the influence of environmental brightness, the RGB parameters are converted into HSI color format.

Figure 2. The images of capacitors with different capacitances values: (a) 20 pF (red), (b) 30 pF (cyan) and (c) 40 pF (yellow)

Fig.3 displays the calculated characteristic hue and saturation values of capacitors with different capacitances. According to Fig.3, the area where the HS values of red, cyan and yellow distributes is deemed as the feature HS value areas of the corresponding capacitors. According to Fig.3, the areas where the HS values of red, cyan and yellow distribute is considered as the feature HS values of the corresponding capacitors. It is observed that there are no overlapped areas of HS values. The hue of red capacitor ranges from 5 to 8, and its saturation ranges from 70 to 80. The hue of cyan ranges from 170 to 180, and its saturation ranges from 45 to 97. The hue of yellow ranges from 48 to 52, and its saturation ranges from 80 to 87. Based on these regions of different characteristic hues and saturation values, the appropriate segmentation threshold could be set, which is the key parameter to accurately identifying different capacitors.
4. Conclusion
In conclusion, an automation system based on computer vision is set up for the identification of capacitors with different capacitances in this study. By employing a CCD industrial camera, the images of capacitors on the industrial assembly line are obtained in real time. In order to avoid the effect of environmental brightness, the obtained images based on RGB model are transformed into HSI color format. Then, the established computer vision system could accurately and effectively determine the capacitances of the capacitors by colors according to the calculated characteristic hue and saturation values. According to the threshold, the image segmentation from the hue and saturation diagram is performed. At last, the capacitors with different capacitances could be identified and determined, which would provide accurate information for subsequent robot arm recognition, location,
collection, and other operations. By using the computer vision system in the industrial assembly line, the automation level and product quality of industrial production could be greatly improved.

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