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A robust vision inspection system for detecting surface defects of film capacitors

Yuxiang Yang [a], Zheng-Jun Zha [b,*], Mingyu Gao [a], Zhiwei He [a]

[a] Department of Electronics Information, Hangzhou Dianzi University, China
[b] University of Science and Technology of China, China

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ABSTRACT

This paper presents a robust vision inspection system for detecting the surface defects of film capacitors. In particular, we use a novel Non-subsampled Contourlet Transform (NSCT) based algorithm to detect the surface defects. Then, the detection results are sent to the mechanical separation system via a serial port. The defective capacitors are peeled off from the production line by motor. The proposed system can improve the detection efficiency. It thus can improve the product quality and reduce production costs. Experimental results have demonstrated that the system achieves superior performance over other state-of-the-art solutions. Moreover, with the system, large-scale vision data of capacitor surfaces can be collected and used to supervise capacitor manufacturing process.

1. Introduction

With the continuous development of industry and information technology, film capacitors are widely used in electronic devices, and the demand is rapidly rising [1]. The production of film capacitor can be mainly divided into winding, coating and welding processes. In the coating step, due to technical limitations, uneven surface defects will appear on the capacitor surfaces, as shown in Fig. 1. In the actual industrial production process, surface defect inspection of capacitors still relies on the traditional manual detection. The labor intensity and the workload are very large. Besides, limited to the impact of the human visual sensitivity, manual detection method is unable to accurately and reliably capture defect information, and will easily cause a lot of missing and false detections. Moreover, careless operation will unfortunately cause the secondary damage to the film capacitors.

In contrast to human inspection, machine vision based automatic inspection techniques have the advantage of high efficiency, low cost and objectivity. In addition, with automatic visual inspection techniques, we can efficiently construct a vision big data of capacitor surfaces. Using such a vision big data, problems of the production line can be timely discovered, and the production quality will be greatly improved. In the last twenty years, automatic visual inspection has been benefited from the steady development of machine vision, and has been widely applied to industrial defect inspection, whose applications now embrace a wide range of very diverse industrial products, such as electromechanical parts [2–5], LCD panel [6], paper making industry [7,8], wood [9], textile [10] as well as food and agricultural products [11]. However, for the film capacitor making industry with high-automation and high-speed requirements, how to integrate the automatic machine vision inspection system with the original production line is a challenging work.

In this paper, we propose a robust vision inspection system for assessing film capacitor defects. In particular, the proposed system is made up of a LCD screen, four independent image processing systems and a mechanical

* Corresponding author.
E-mail address: junzzustc@gmail.com (Z.-J. Zha).

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separation system. Owing to the real-time requirement of production line, the image processing algorithms applied in our system need to have low computational complexity and high efficiency. Specifically, we apply a novel Non-subsampled Contourlet Transform (NSCT) with adaptive threshold to inspect the surface defects of capacitors. Then, the inspection results are sent via the serial port to the mechanical separation system, and the defective capacitors are peeled off the production line by a novel motor system. The proposed system can well adapt the original production line, and experimental results have demonstrated that the system can improve the detection efficiency and reduce the production costs significantly.

The rest of the paper is organized as follows: The related work is given in Section 2. The overview of the system is described in Section 3. The proposed inspection algorithm based on NSCT is illustrated in Section 4. In Section 5, experimental results are detailed to justify the

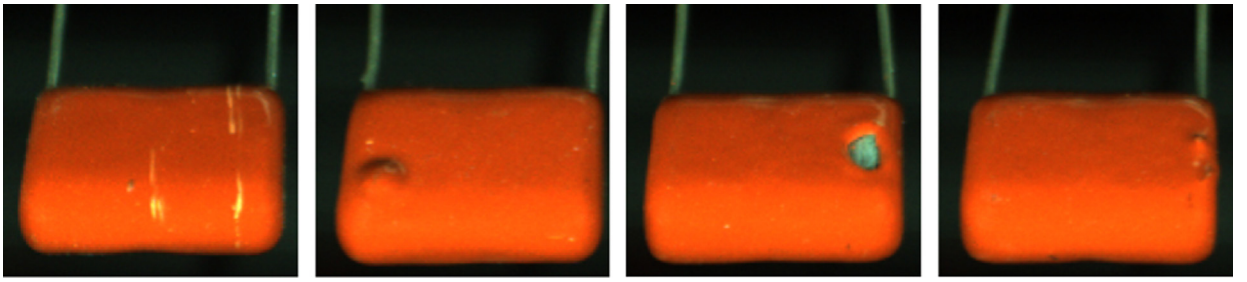

Fig. 1. The main surface defects of film capacitors.

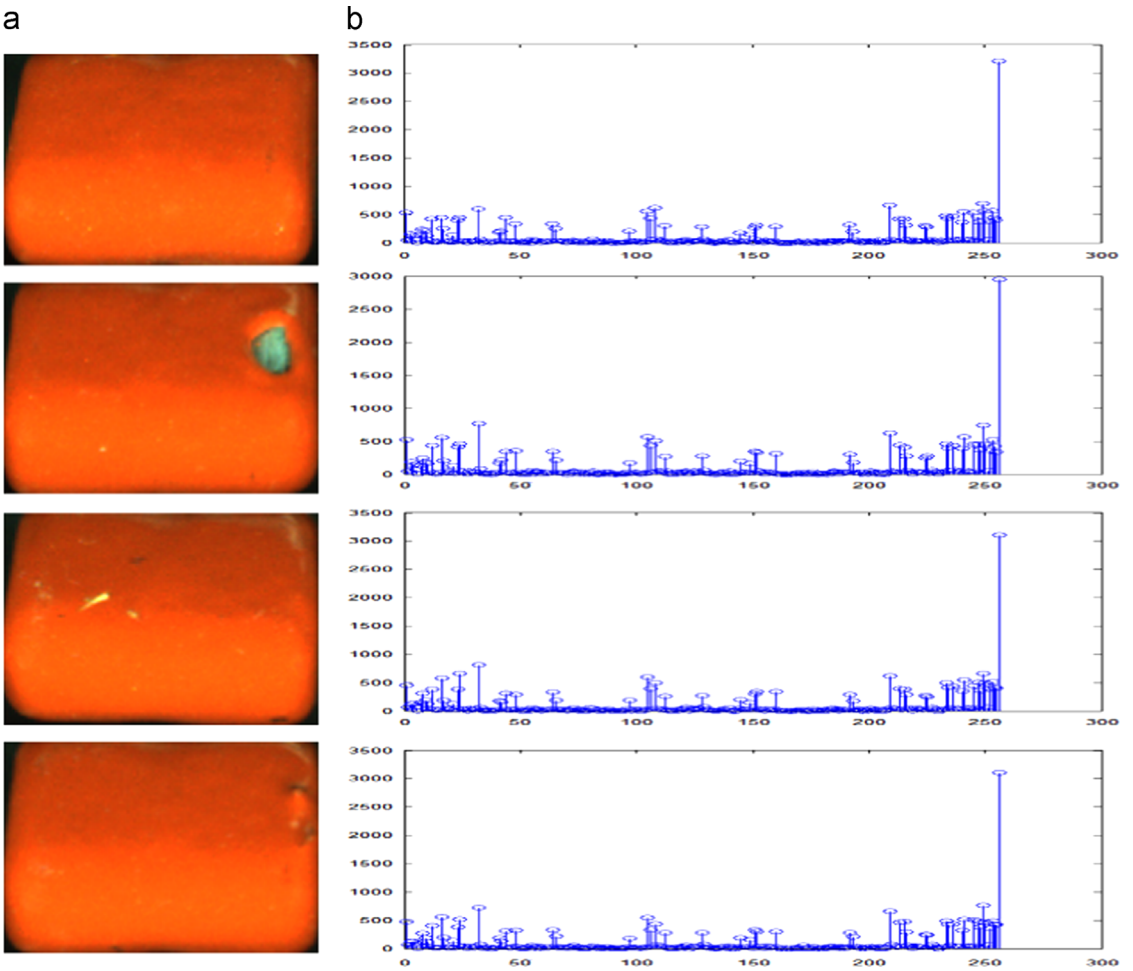

Fig. 2. The results of LBP operator [16] for film capacitors: (a) non-defective and different defective capacitors and (b) the corresponding LBP histograms. Note that LBP histograms of non-defective and different defective capacitors are nearly the same.