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Review

Applications of computer vision techniques to cotton foreign matter inspection: A review

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ABSTRACT

Cotton is an important crop throughout the world, and its quality plays a significant role in its profitability and marketability. Foreign matter in cotton can cause damage to spinning, weaving, and dyeing and thus seriously affects the quality of cotton products. Conventional methods including inspection by human workers and instrument based approaches such as photoelectric detection and ultrasonic detection are time-consuming, labor-intensive, and sometimes inaccurate. As a non-destructive, cost-effective, rapid, and objective inspection tool, computer vision has been widely used in cotton foreign matter inspection. In this review, the basic concepts, components, and image acquisition modes of computer vision techniques are presented. The improvements in image processing and analysis of foreign matter in cotton are introduced, and several different computer vision systems that have been created to detect foreign matter are reviewed to highlight the potential for the inspection of foreign matter. Considering the progress made to solve this type of problem, we also suggest some directions for future research.

Contents

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1. Introduction

Cotton is an important resource related to numerous nations' economies. Cotton processing and cotton spinning play an important role in the Chinese national economy in particular. When harvesting, cotton is subject to contamination from numerous sources, and a variety of foreign matter may become mixed with raw cotton during cotton processing. Foreign matter, also called foreign materials, foreign contaminants, or cotton trash, refers to both botanical trash and non-botanical trash which are inadvertently mixed with cotton during picking, storing, drying, transporting, purchasing, and processing (Yang et al., 2009a). Botanical trash includes hull, leaf, bark, seed coat, etc. Non-botanical trash is also called foreign fibers including hair, binding rope, plastic film, candy wrappers, polypropylene twine, etc. Foreign matter is difficult to remove and is easily broken into countless tiny parts that in turn increase the breakability of cotton yarn and reduce the processing efficiency and market value according to the cotton grading system. Foreign matter also affects the quality of yarn and woven cloth as well as the appearance of dyed cloth.

Conventional detection methods for foreign matter in cotton have been performed by human workers, but most of these manual inspections are time-consuming, inefficient, and have unverifiable accuracy rates (Yang et al., 2009b; Li et al., 2006). The poor performance of conventional detection methods and the bad effect of foreign matter on cotton industry have attracted great attention from research institutes and cotton enterprises (Luo, 2007). Researchers in China and abroad have been conducting research on foreign matter detection for some time and have made significant progress. Several instrumental and sensory methods have been developed for the detection of foreign matter. The main detecting principles can be categorized into three types: photoelectric detection, ultrasonic detection, and optical recognition (Shi, 2007).

Photoelectric detection detects foreign matter in cotton using a phototransistor. It is used to identify foreign matter according to the color variation between cotton and foreign matter. The method is simple and has a low manufacturing cost. However, the detection rate is low due to the great attenuation of sensitivity and poor stability of the phototransistor. It is also impossible to identify tiny colored foreign matter as well as foreign matter that has a similar brightness to cotton, such as white polypropylene (Chang, 2006).

Ultrasonic sensors transmit ultrasonic waves at the cotton and receive the reflected information. Ultrasonic signals reflected by objects with different densities are different. Therefore, the foreign matter is identified by signal processing and comparison because the signals reflected by foreign matter are typically stronger than those reflected by cotton. It can be used to detect certain types of foreign matter such as bulked paper strips, cloth strips, plastics, etc. However, the speed of ultrasonic transmission is lower than that of light, so the identification process is slow and sometimes cannot be completed in the time allotted. In addition, ultrasonic sensors are not able to identify small foreign matter (Chang, 2006).

Using a high-speed CCD or CMOS camera, the optical detection method scans the surface of the cotton layer, and the images generated from the scanning signals are sent to a computer system for processing. Both line scan cameras and area scan cameras can be used, the first of which is more flexible and convenient. In contrast to the two former methods, the advantage to optical detection is that it can recognize small foreign matter in cotton and meet the requirements of real time inspection. The only disadvantage is the high cost of manufacturing the system (Chang, 2006). However, with scientific and technological development, the cost will drop.

Based on the optical detection principle, computer vision techniques have the advantages of cost effectiveness, consistency, superior speed, objectiveness, and accuracy. With the advances in hardware and software for digital image processing, automatic inspection systems known as computer vision or machine vision, mainly based on camera-computer technology, have been investigated for the sensory analysis of agricultural and food products and have been proven successful for the objective measurement of various agricultural products (Brosnan and Sun, 2004). Furthermore, applications of these techniques have now expanded to various areas such as medical diagnosis, automatic manufacturing and surveillance, remote sensing, technical diagnostics, and autonomous vehicle and robot guidance (Brosnan and Sun, 2002). In recent years, computer vision systems have been applied to the textile industries (Tantaswadi et al., 1999; Millman et al., 2001; Abouelela et al., 2005) for inspection and/or removal of foreign matter in cotton (Lieberman et al., 1998) and wool (Zhang et al., 2005a–c; Su et al., 2006). These systems hold great potential for the inspection of cotton foreign matter.

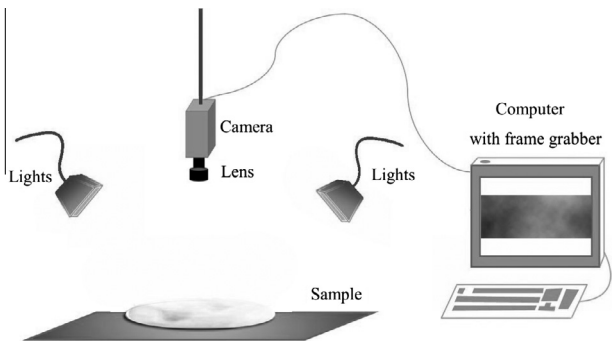

Fig. 1. Components of a basic computer vision system.