X-RAY MICROTOMOGRAPHIC IMAGE ANALYSIS FOR IDENTIFICATION OF COTTON CONTAMINANTS

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Abstract

Cotton is subject to contamination from a variety of sources, including surrounding vegetation, insects, and materials involved in its harvesting and handling. Few of these contaminants (e.g., leaves, bark, seed-coat fragments, polypropylene) survive the ginning process, and have a direct impact on its grade and, hence, its economic value. Current methods used for estimation and detection of foreign materials in cotton include gravimetrics [e.g., Shirley Analyzer, and the Advanced Fiber Information System (AFIS)], and surface scanners [e.g., trashmeters of High-Volume Instruments (HVI)].

A novel technology for the precise identification and measurement of foreign materials in cotton lint is presented. This new technology combines new advances in x-ray microtomographic imaging, with state-of-the-art image analysis techniques to improve the industry's ability to rapidly and precisely characterize and record the contaminants in cotton lint. This technology differs fundamentally from existing work in its ability to (1) capture material density and composition for improved sensitivity, (2) generate and automatically analyze volumetric images for increased size and shape discrimination and identification accuracy, and (3) provide a superior detection resolution.

The technology involves the use of an x-ray scanner (40kVp/1000µA source, object size < 30mm, spatial resolution of 40µm). X rays emitted by the source pass through the sample and the collected projections are recorded by a 768x576 pixel, 8-bit camera and are saved on a computer. In any contaminated sample, regions of relative high density (i.e., contaminants) give rise to projections different from those caused by regions of lower density (cotton). Many such projections are obtained by rotating the sample through a range of different angles. A reconstruction algorithm combines all the different projections and generates a slice-by-slice volumetric scan of the sample. This procedure is formally known as x-ray microtomography. Then the slices may either be studied individually, or they may be combined to generate a three-dimensional volume. Due to the high penetration power of the x-rays, one is able to locate, with precision, the presence of any impurity in the sample. Furthermore, because of the volumetric nature of the output data, one is able to estimate the shape of the impurity with a high degree of accuracy.

For the purpose of this research, we have chosen to study three major sources of cotton contamination; namely, bark, seed-coat fragments, and polypropylene. Samples were prepared by placing a controlled amount of impurity of known type in cleaned cotton and were subsequently scanned over the available range of voltages (20-40kVp) and currents (300-1000µA). The behavior of the machine over the entire range and the corresponding attenuation coefficients (measure of density) of the different impurities were measured. It was found that the attenuation coefficients of the three contaminants differ considerably, and therefore, may be used as one of the viable features to effectively perform the segmentation and classification of the impurities.

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