CLASSIFICATION OF COTTON TRASH WITH FEATURES EXTRACTED FROM FLUORESCENT IMAGES

Adnan Mustafic
Changying Li
University of Georgia
Athens, GA

Abstract

A fluorescent imaging setup consisting of blue LED and the UV LED excitation sources with an SLR camera was constructed based on the excitation/emission analysis by fluorescence spectroscopy. Under the blue LED excitation light the following cotton trash types were imaged: bark, brown leaf, bract, green leaf, and hull. Under the UV LED excitation light the following cotton trash types were imaged: paper, plastic packaging, seed, seed coat (inner), and seed coat (outer). Images of botanical and non-botanical cotton trash on top a lint layer were acquired and subjected to a series of image processing steps to extract the information from the regions of interest. The analysis of images considered two color models: RGB and HSV. From each of the color models, specific image ratios and channels were extracted and subjected to statistical analysis to determine their potential for classification of cotton trash. Linear Discriminant Analysis (LDA) was applied in order to see whether image ratios and channels can be used as classification inputs. Classification rates of 100 % were achieved for paper and plastic packaging, and rates of at least 80 % were achieved for green leaf, hull, and outer portion of the seed coat.

Introduction

Cotton is a cellulosic fiber from the genus *Gossypium* consisting of carbohydrate polymers. Out of four domesticated species, Upland cotton (*Gossypium hirsutum*) accounts for over 90% of the cotton harvested worldwide (Wakelyn et al., 2007). Cotton is mainly used for the production of various apparel and products, animal feed, and food for human production (e.g. cottonseed oil). Two operations with the most impact on cotton quality are harvesting and ginning. Unlike rest of the world where most of cotton is harvested by hand, in the US cotton is harvested with cotton pickers and cotton strippers, with latter being the more prevalent type. Since cotton harvesters in addition to fibers remove a number of other contaminants from the plant and the field, the resultant seed cotton needs to be cleaned in gins. At gins, most trash particles are moved from seed cotton, however smaller trash particles remain mixed with lint. Following ginning, lint is sent to classing office where it undergoes quality assessment. Quality assessment is conducted via human classers and instruments. Instruments like the High Volume Instrument (HVI) provide a more objective grade, and while it provides estimate of the amount of trash in the sample under observation, it does not provide information regarding the specific types of trash present.

To investigate and provide information pertaining to the differentiation and classification of cotton trash mixed with lint, imaging methods based on it have been developed. Xu et al. developed a color imaging system to analyze whether its information matches the color properties of cotton obtained from colorimeters and human classers (Xu et al., 1997). The comparison results were highly correlated for each of the data sets from different sources. Since geometric features like size can change during ginning, using them to classify cotton trash is not reliable. A better approach attempted by Xu et al. is to use color features less susceptible to change (Xu et al., 1999). Features from the L*a*b color model from bark, leaf, and seed coat were used as inputs for the sum of squares, fuzzy clustering, and artificial neural networks. Classification rates of 95 % were obtained in the case of neural networks, while for bark and leaf, classification rates ranged from, 93% to 83%.

The current study utilizes features extracted from fluorescent images to classify cotton trash categories. Images of cotton trash placed on lint surface were converted to the RGB and HSV color models, and their regions of interests analyzed. Features from the RGB and HSV color models were used as inputs for the Linear Discriminant Analysis (LDA), and classification of botanical and non-botanical trash was performed.

Materials and Methods

Botanical trash samples were manually removed from seed cotton of four cultivars harvested in 2012. The types used were bark, brown leaf, green leaf, hull, and seed coat. For seed coat two different types were considered due to their distinct appearance: inner part and the outer part. Non-botanical trash types included paper and plastic packaging. The plastic bale packaging was received from the cotton Micro Gin (Tifton, GA), while paper and twine were purchased from local stores.

Individual samples of cotton trash were placed on a layer of lint and positioned in the camera field of view, while the excitation sources provided illumination (Figure 1). The camera raw images were converted to TIF format and denoised. For each image, thresholding was applied and information from the region of interest extracted. The same procedure was repeated for the RGB and HSV images. Features from individual color models were used as inputs for LDA classification, where 50% of the dataset was used for training and 50% for testing.

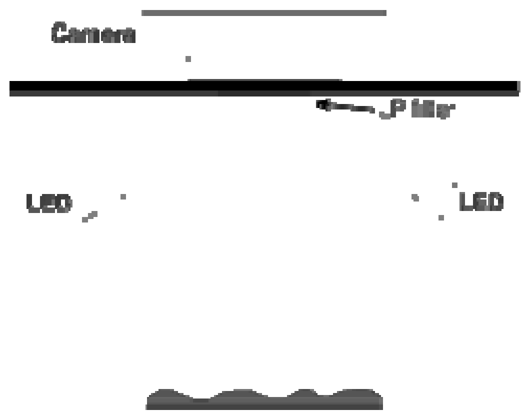

Figure 1: Fluorescent Imaging System Schematic

Results

LDA classification results for trash categories imaged under blue LED excitation light (Table 1) in the instance when only the individual features from one color model were used, shows the highest classification rate for green leaf (90%) and hull (77%), followed by bark (50%) and brown leaf (40%). By combining features from multiple color models (RGB and HSV), classification rates were improved for all four trash categories. Classification rates of 77% were achieved for bark, 47% for brown leaf, 97% for green leaf, and 87% for hull.

LDA classification for cotton trash categories imaged under UV excitation light (Table 2) show a classification rate of 100% obtained under any of the individual color models and their combination in the case of paper. Plastic packaging has the classification rate of 100% in all cases except when features from the RGB color model features were used (97%). Inner part of the seed coat had the highest classification rate of 80% when features from RGB and HSV color spaces were combined, while for the outer part of the seed coat, the classification rate of 73% was obtained with the same feature combination. Paper and plastic packaging achieved the highest classification rate if features from only one color model were used, and seed coat (inner and outer) improved their classification rate with the combination of features from both color models.

Table 1: Classification rates (%) of cotton trash types imaged under blue LED excitation light.

Trash Type	HSV	RGB	HSV+RGB
Bark	50	33	77
Br. Leaf	40	10	47
Gr. Leaf	90	40	97
Hull	70	77	87

Table 2: Classification rates (%) of cotton trash types imaged under UV LED excitation light.

Trash Type	HSV	RGB	HSV+RGB
Paper	100	100	100
Pl. Pack.	100	97	100
Seed Coat (Inner)	73	67	80
Seed Coat (Outer)	57	33	73

Summary

Features extracted from fluorescent images of cotton trash placed on top of lint were used for classification purposes with the LDA. For paper and plastic packaging, highest classification rates were achieved if the features used were only from one color model, either RGB or HSV. For all types of botanical trash (bark, brown leaf, green leaf, hull, seed coat (inner and outer)) the classification rates were markedly improved if a combination of features from more than one color model was used. A major contribution was the addition of the luminescent component from the HSV color model due to its ability to provide information irrespective of color components. The future studies will focus on using the color model information and performing validation of samples with mixed trash.

Acknowledgments

We are grateful for funding from the Cotton Incorporated and Georgia Cotton Commission, and would like to thank Andy Knowlton from UGA Micro Gin in Tifton, GA for providing us with cotton samples.

References

Wakelyn, P. J., N.R. Bertoniere, A.D. French, D.P. Thibodeaux, B.A. Triplett, M.A. Rousselle, W.R. Goynes Jr., J.V. Edwards, L. Hunter, and D.D. McAlister. 2007. Cotton Fiber Chemistry and Technology. CRC Press, Boca Raton, FL.

Xu, Bugao, C. Fang, R. Huang, and M.D. Watson. 1997. Chromatic Image Analysis for Cotton Trash and Color Measurements. Textile Research Journal. 67(12): 881-890.

Xu, Bugao, C. Fang, and MD Watson. 1999. Clustering Analysis for Cotton Trash Classification. Textile Research Journal. 69(9): 656-662.