MEASURE THE COLOR DISTRIBUTION OF A COTTON SAMPLE USING IMAGE ANALYSIS

Xiaoliang Cui
James Rodgers
USDA, ARS, SRRC
New Orleans, LA
Yiyun Cai
Louisiana State University
Baton Rouge, LA
Vikki Martin
Mike Watson
Cotton Incorporated
Cary, NC

Abstract

The most commonly used measurement of cotton color is by the colorimeter principal that reports the sample's color grade. However, the color distribution and variation within the sample are not reported. Obtaining color distributions of cotton samples will enable a more comprehensive evaluation of cotton color characteristics. We report our preliminary results on using image analysis as a method to study cotton color distributions. High-resolution color images were obtained by using a color scanner. For each image, overall Rd and +b values were computed and compared to those obtained from HVI measurement. Rd and +b values of sub-areas of every image were computed to analyze the color distribution. Intra-sample and inter-sample variations of Rd, +b values and color grades were examined. Results show that though inter-sample color variation of a cotton is very small, the intra-sample variation is significant.

Introduction

Cotton color is an important parameter in trade and textile processing. Cotton color reflects other cotton physical properties and is associated with the quality of textile products. As a property of a natural product, cotton color has distribution and variation even for the same cotton. The distribution or variation of the cotton color could indicate the variation in other fiber physical properties that influence the textile processability and product quality.

The most commonly used method for measuring cotton color is by a colorimeter, and it is not capable of measuring cotton color distribution and variation within one sample (intra-sample variation) during the measurement, only overall Rd and +b values, consequently the color grade, are reported. The earlier studies on cotton color measurement mainly focused on improving the measurement of the overall color grade of a sample, from the very early disc-colorimeter to the recent implementations of modern techniques such as fuzzy logic and neural network (Nickerson 1946, Kang and Kim 2002, Xu *et al* 2002). Discussion on the intra-sample distribution and variation is lacking in the current literature.

We used a color image analysis method to measure cotton color distribution. Instead of an overall color grade, our research focuses on the intra-sample variation and distribution of color within the measurement window upon which a cotton sample is placed. We expect the results can be used to better evaluate cotton quality and enhance the rapid test of cotton color. Such a technique also has the potential of integrating color and trash measurement together.

Materials and Methods

A total of 110 measurements were carried out (22 cottons, each with 5 samples, each sample was measured once). These samples have a wide range of color values. Before the tests, all samples were kept at the standard condition (70C and RH 65%) for over 24 hours.

Color was measured by using 1) an HVI-1000, and 2) an Epson Perfection V500 scanner. When using the scanner, the sample was pressed on the scan surface of about 4.5" x 4.5" under a 5 kg (11 lb) weight. The scan resolution was 400 dpi. Images were stored in 48-bit sRGB format. For each image, a 3.5"x3.5" area was selected to simulate the size of the HVI color and trash measurement window, which has the same area. sRGB values of each pixel were used as inputs to compute Rd, +b values and then color grades.

The 3.5"x3.5" area was divided into sub-areas, the sub-area size ranges from ½" x ½", ¼" x ¼", to a single pixel. Each sub-area's color values and grades were computed. Figure 1 shows an example of sub-area ½" x ½". The distributions and variations were then generated from these values of sub-areas.

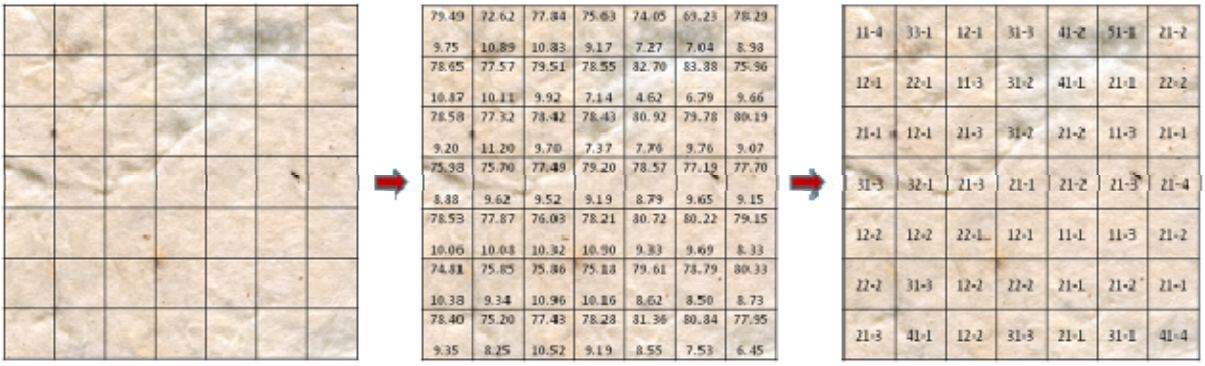
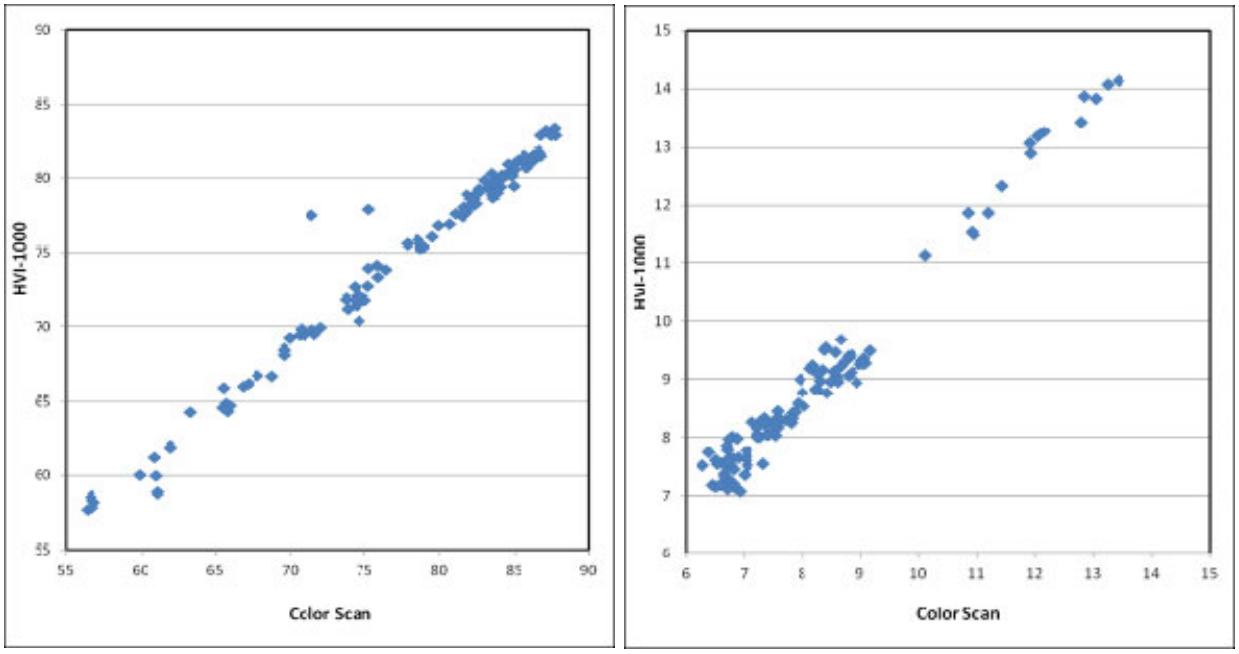


Figure 1. Divided the image into sub-areas and computed their Rd, +b values and grades

Results and Discussion

Firstly, we examined the Rd, +b values obtained from the image analysis to see if they could match HVI results. Figures 2(a) and (b) show the comparisons of Rd and +b values from scanned images and HVI-1000 results. It can be seen that though the scanned Rd and +b values are slightly different from those of HVI, the linearity between them is excellent (both have a correlation coefficient of 0.99). The comparisons indicate that the color values from the scanner can be accurately and sufficiently associated with HVI color measurements. The small difference may be considered as a variation between devices.



(a) Rd (b) +b

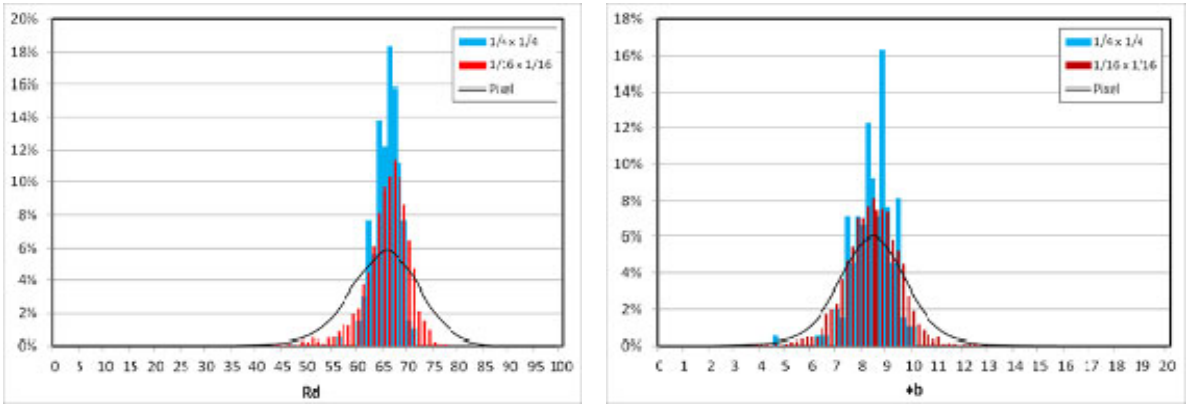
Figure 2 Comparisons between color values from scanned images and those from HVI

Table 1 shows the average inter-sample Coefficient of Variations (CV_{inter}) of Rd and +b values. For the same cotton, the color CVs from the 3.5"x3.5" window are very small. It can be seen that the variation of +b is higher than the variation of Rd.

Table 1 Average inter-sample variations of Rd and +b

Devices	Rd_CV_{inter}	+b_CV_{inter}
HVI-1000	0.65%	1.92%
Scanner	0.82%	2.50%

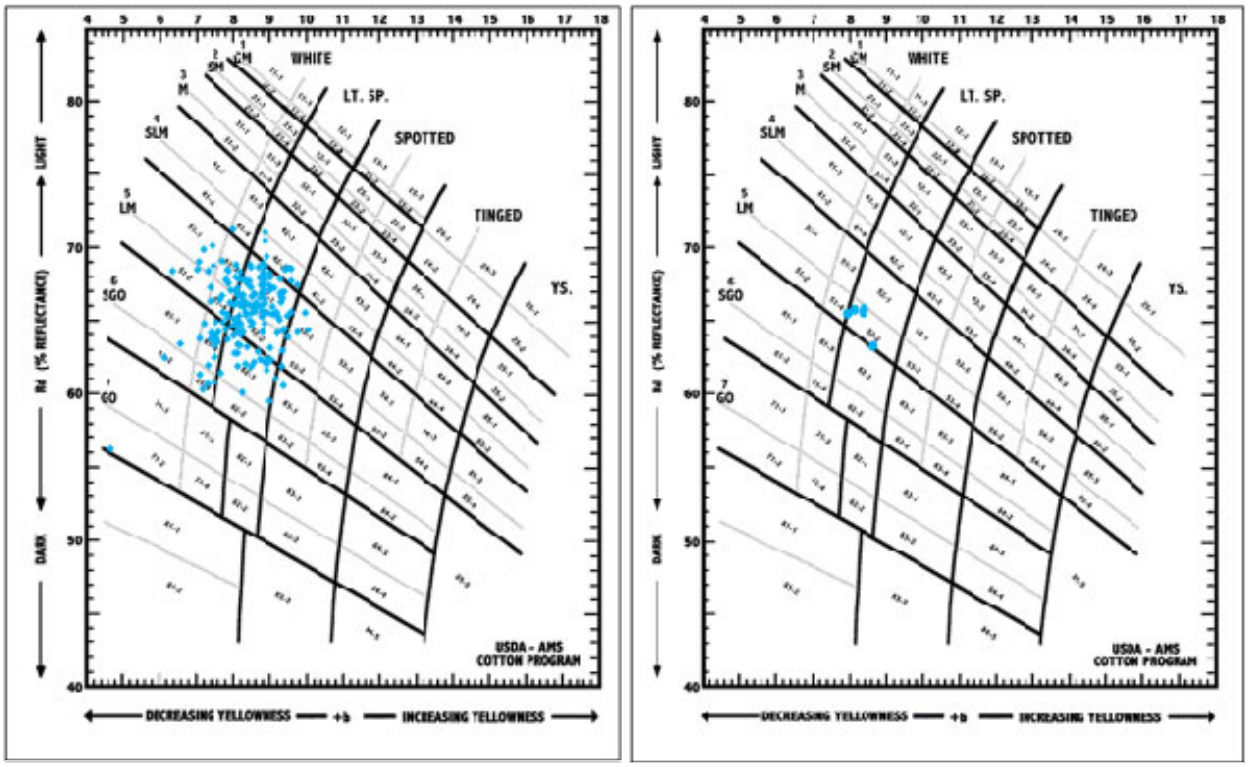
Figures 3(a) and (b) displays the histograms of Rd and +b values of a sample. From the histograms, it can be seen that generally if the sub-area size is bigger, the Rd and +b show higher concentration on a limited number of certain values.



(a) Rd (b) +b

Figure 3 Histograms of Rd and +b with respect to sub-area size

Figures 4(a) and (b) show intra-sample and inter-sample color grade distributions of a cotton. The figures were generated by plotting the intra-sample distributions of Rd and +b on the USDA cotton color grade chart (Figure 5(a), paired with the overall grades obtained from different reps of the same cotton (Figure 4(b)). The sub-area size is ¼" x ¼", which means a measurement window contains 196 sub-areas. The plots indicate that though the color grades from different reps of the same cotton are very uniform (Figure 4(b)), intra-sample color variation is significant. On the chart, this variation covers a region that contains both higher grades and lower grades (Figure 4 (a)).



(a) Colors of sub-areas of sample# 2 (b) Colors of five samples

Figure 5 Intra-sample and inter-sample color grade distributions of a cotton

Conclusions

The current cotton color measurement method by colorimeter principal does not report intra-sample color distribution and variation. We present a new approach to use a color image analysis method to measure intra-sample cotton color distribution. We obtained Rd and +b values by the color image analysis method and consequently color grades, which give good match to HVI measurement results. The inter-sample color variations of a cotton is very small, while the intra-sample Rd and +b variations are significant in our preliminary results. The intra-sample variation of Rd and +b increase with the decrease of sub-area size (the increase of sub-area number). Similarly, the inter-sample variations of the color grades are very small, while the intra-sample color grade has a wide distribution that spans over a large range of color grades.

Disclaimer

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References

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