ADDITIONAL FACTORS FOR HVI COLOR GRADING

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Abstract

One hundred cotton samples have been evaluated by both instrumentation and cotton classer for color grade. There is agreement between USDA HVI color grade and classer on fifty of these cottons. There is disagreement between USDA HVI color grade and classer on the other fifty. It has been found that redness, variation in yellowness, and yellow spot area can be used to increase agreement between instrumented systems and the cotton classer. The need for a measure of redness and variation in yellowness is clearly demonstrated.

Introduction

Color is vitally important to manufacturers and an accurate call on color is extremely important. As a result, instrumented color systems have been developed that attempt to make this call which cotton classers have made for many years. Assuming that the cotton classer can correctly evaluate color grade, a goal becomes one where HVI color grade matching with classer grade is predicted in all cases. Unfortunately, this is not the situation and much effort has been put forward to identify instrument system factors that enhance predictability of classer grade.

Materials and Methods

The USDA has provided two groups of cottons for which HVI color grade agrees and disagrees with classer grade, respectively. The two groups consist of fifty cotton samples each, for a total of one hundred samples. The cottons do not cover the whole range of classer grades, but are restricted to White, Light Spotted and Spotted. The discrepancies are between the first two classifications and, hence, very localized for overall color/grade translation.

The classer observes variation in color, trash, yellow spot distribution and other visual effects in the process of grading. This variation is deemed important and has been instrumented in this study. A color scanner has been used to obtain color images from which yellowness variation [variation in b* in CIE standardization] and yellow spot area can be obtained. The color scanner image is converted pixel-by-pixel in an algorithmic translation of r,g and b parameters to CIE color space parameters L*, a* and b*. Spatial variation in yellowness and yellow spot is easily obtained from this. An optical spectrometer, manufactured by *Ocean Optics,* was used to obtain CIE L*, a* and b* means. (Billmeyer and Saltzman,1981).

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Results and Discussion

The color/grade translation chart is a 2-D graph of Rd versus +b, on which is overlaid the cotton classer=s color grade (white, light spotted, spotted, tinged and yellow tinged) and scale preparation (GM, SM, M, SLM, LM, SGO and GO). The HVI system currently provides Rd and +b parameters obtained from an average response of reflected and color-filtered light which is translated into a number representative of color grade.

The one-hundred cotton samples examined here cover a wide range of preparations from good middling (GM) to strict good ordinary(SGO). That is, reflectance or Rd varies widely from about 50 to 85. Color is exclusively limited to white,light spotted and spotted, with +b falling between about 8 and 11. All disagreeing cottons are between an HVI designation as white and the classer=s color grading as light spotted. The following steps demonstrate why variation in visible features and the introduction of a previously discarded redness measure can bring HVI color grade and classer grade into high agreement.

All one-hundred samples were scanned for color images and r,g,b values obtained for the complete array of pixels (436x450). The r,g,b values are converted into CIE tristimulus values X,Y,Z which, in turn, are translated into CIE color space L*, a*, b* . The L* is a measure of lightness and comparable, but not equivalent to HVI Rd. Similarly, b* is a measure of yellowness, analogous to +b on the Hunter color scale. The CIE color space parameter a* is a measure of redness and has not been an HVI color grade factor in the past because of its narrow range compared to factors describing yellowness. From the pixel L*,a*,b* values, computation of distribution parameters such as variance is carried out. Because the spectrometer measures the whole visible spectral distribution, the means for L*, a*and b* are superior to the scanner approach. These means are used in classification of color grade.

The final result, here, is a determination of mean values of L*, a*, and b* and the variation from the means. These results are used to identify parameters that would allow one to discount, i.e., down grade, an HVI color grade category to the next. That is, if HVI color grading by Rd and +b places a cotton in a white grade, should the cotton be downgraded to light spotted by other quantifiable and measurable features that might include spatial variation or the introduction of redness. The downgrading could equally apply between light spotted and spotted under normal circumstances, but the 100 cottons examined here showed no HVI and classer disagreement in these two groups. Incidently, there was also no disagreement in grade preparation and, hence, reflectance is not a factor considered for decision purposes.

Of the one-hundred cottons, we begin with a fifty-percent (**50%**) agreement between HVI color grade and classer color grade. Hence, we consider various imaging parameters and select appropriate thresholds for downgrading the HVI color grade. Of those parameters, the first considered is yellow spot area which is *a priori* considered important to a classer=s assignment of color grade into light spotted, spotted, tinged and yellow spot. Figure 1 displays the results obtained from color images for the three color grades covered by the one-hundred cotton samples. The means are obtained from replicated images. As observed, white color grade has almost no discernable yellow spot, whereas light spotted and spotted classer grades rise rapidly in its contribution to classification in the two latter grade categories. The contribution of yellow spot is directly connected to classification; the real question is the extent to which yellow spot area should be used to downgrade color grade from light spotted to spotted, or from white to light spotted. For the 100 cottons examined, a downgrade was made from white to light spotted when the fraction of yellow spot area exceeded 0.05 . Below this, an HVI color grade remained white in classification. The result on downgrade using the decision procedure raises the overall grading agreement of the 100 cottons to fifty-seven percent (**57%**).

HVI yellowness, +b, is expected to be closely related to classer grade. Its contribution is, in fact, the primary basis for relationship to classer color grade. But as noted, it alone does not predict fully classer color grade and, in this specific study, is only successful for half of the one-hundred cottons. When imaging technique and spatial analysis considerations are applied, two additional factors likely affect classer grading. One of these is contrast in texture analysis which is the spread of grey level difference histogram. This parameter for these one hundred cottons, as used to downgrade white to light spotted color grade, raises the agreement level by nine percent (9%). The means of b*-contrast compared to classer color grade is presented in Figure 2. It is the tendency to increase with classer grade that suggests that it is a parameter that can be used to downgrade a white to light spotted. But as found, the contribution to producing total agreement between HVI color grade and classer color grade is limited. This contribution of b* contrast raises the overall agreement level to fifty-nine percent (**59%**).

More important is the contribution that variance of b* might make to the decision to downgrade cottons in disagreement between USDA HVI and the cotton classer. The variation in b* for white, light spotted, and spotted cottons is presented in Figure 3. The variation in b* rises along with classer color grade and, hence, can be used to search for an effect for downgrade decision making. The decision threshold for downgrading these one hundred cottons from white to light spotted is that the variation in b* > 1.1 . This threshold is the mid-value between white and light spotted levels of these one-hundred cottons (Fig.3). When this decision making is applied, the agreement between USDA HVI color grade and classer color grade is increased by 26 percentage points, raising the overall agreement to **76%**.

Finally, it has been previously suggested that the redness of a cotton might be a significant factor in color grading. Redness normally displays a small range between cottons relative to the overall range in yellowness. Furthermore, redness has not been as easily determined by CIE standardized guidelines and incorporated into color measuring systems useful to high volume testing. However, the *Ocean Optics* spectrometer and available software available to our studies provides a CIE standardized redness measure a*. The scanner imaging system cannot handle this determination with the desired accuracy needed. The mean spectrometer measurement of a* has been obtained by using the color head of the HVI system, with the filter accessories removed and with the spectrometer sensor to measure reflected light from each of the one hundred samples. Values of a* have been related to classer color grade and the results are shown in Figure 4. The redness of cottons normally increases with classer grade and, hence, can be considered a parameter for downgrading HVI color grade. This has been done on the one-hundred cottons examined, using a decision threshold of a*>2.1 in downgrading a USDA HVI color from white to light spotted. When this is carried out, agreement between USDA HVI color and classer grade in raised by 44 percentage points to a total of ninety-four percent **(94%**). Thus, the importance of using a* in color grading by HVI color systems is clearly demonstrated.

When all of the previous decision making parameters are combined, the agreement between USDA HVI color grading and classer color grade rises to **95%**, for these one-hundred cottons. This cumulative result is summarized in Figure 5. This is an exceptional result and suggests some of the additional considerations that could and should be built into future HVI color systems.

Conclusions

There is improvement in color grading between HVI and cotton classer by adding a*, b* variance, and yellow spots to the HVI color grading system. Furthermore, a* is possibly the most important parameter, with b* variance close by.

References

Billmeyer, F.W. and M.Saltzman, Principles of Color Technology , 1981. Publisher: John Wiley & Sons.

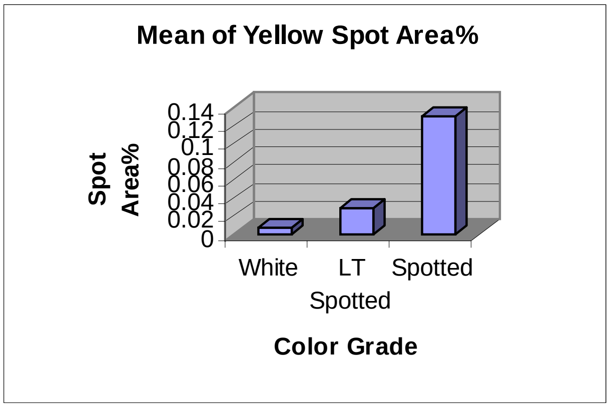

Figure 1. Yellow spot Area versus Color Grade.

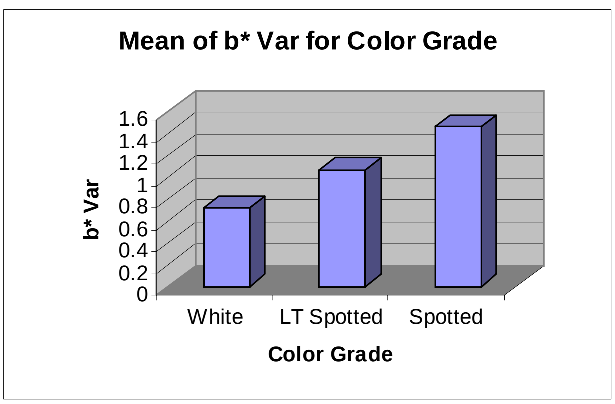

Figure 2. b* Variance versus Color Grade.

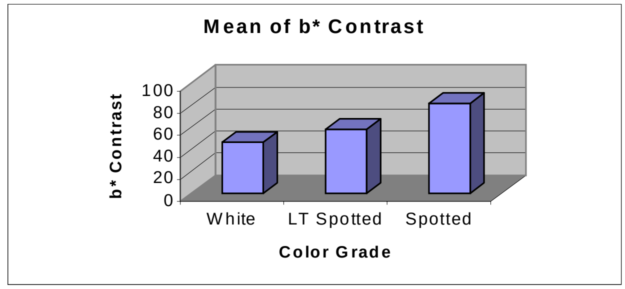

Figure 3. b* Contrast versus Color Grade.

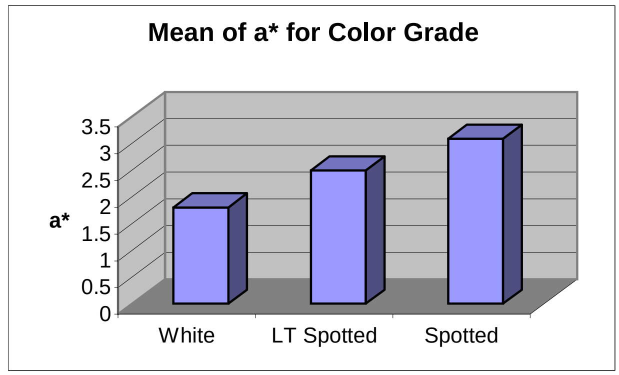

Figure 4. a* versus Color Grade.

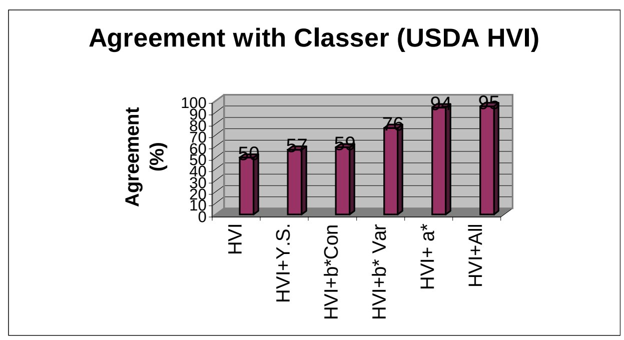

Figure 5. Combination of Effects on HVI and Classer Color Grade Agreement.