Brief Introduction of a New Color Measuring and Matching System

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Abstract

The computer color matching (CCM) systems are more and more to use in color industry. This article has introduced the model of color matching, presenting the color measuring and software system in CCM briefly that have been made ourselves.

Introduction

Color, is eye's consciousness that has been excited by visible spectral energy, and has more and more paid attention to the textile, paint, plastics and other color areas. Computer color matching (CCM) is based on color measure. According to the CIE color system, when the spectrum of sample has measured by spectrometer, we may calculate the chrominance and we may calculate the pigment concentration of sample.

For color matching in practice, we are assuming that the simplified form of Kubelka-Munk (K-M) theory (opaque films) applies[1]:

$K/S = (1-R)^2/2R.$

For mixtures the absorptions (K) and scatterings (S) are individually additive. At each wavelength i

$$(K/S)_{mix} = \Sigma C_i K_i / \Sigma C_i S_i \qquad (1)$$

here R is the reflectance at wavelength i. $\varphi_n = (K/S)_n$ is called K-M function of that delegate the optical characteristic of colorants.

A New Model of Color Matching

In general there are two methods of computer color matching: reflective spectrum matching and tristimulus matching. What is now popular is tristimulus matching, the best known being the method by E. Allen[1]. Through have studied the field of the color matching for near three years, we found some sorry in these two color matching methods (For example, the question of number of colorant, the metameric index, distinguishing the true (or false) concentration recipe yet.) and here we are presenting a new way that can combine the two methods mentioned to create a new one. The brief idea is introduced as follows.

Consider a matching of n colorants. At the 400 to 700 nm range of visible spectrum.

(1) For the textile, the scattering effect of colorants may be ignored, so the K/S in Eq. (1) can be transformed into linear with the product of concentration C and K/S of the n individual colorants. According to the E. Allen's assuming: when the spectrum of the sample and match differ only slightly, and this difference can be approximated by a first-order expansion.

(2) For the matching in the paint, plastics and other color areas, the scattering effect of colorants can't be ignored, Eq. (1) isn't linear equation. According to the spectrum approximately, we may transform this two-constant (K and S) equation into one-constant through building the data-base that are difference textile's (there are three constants in the data-base: R, K and S). Then to calculate the concentration C of color sample.

Using the DS to express the difference of spectrum; DT to express the difference of tristimulus. We may get the model of linear programming color matching[2]:

Target Function:

$$F_{min} = \sum_{j=400nm}^{700nm} (DS)_{ij} + P \sum_{j=400nm}^{700nm} (DT)_{ij} \qquad (2)$$

Constraint equations:

$$|(\text{spectrum of sample})_i - (\text{Spectrum of matching})_{ij}| < DS$$
$$|(\text{Tristimulus of sample})_k \ (\text{Tristimulus of matching})_{ik}| < DT \qquad (3)$$

$i = 1, 2, \ldots\ldots n,$

$j = 400, 410, \ldots\ldots 700$ nm,

$k = x, y, z$

P is the weighting coefficient for difference of tristimulus to put in to indicate that this approach equals a tristimulus match under the spectral approximate match condition in the first order with F being nonzero.

To sum up, this color matching model combines the pure spectrum match and the pure tristimulus match organically by minimizing a linear target function F under linear constraints. This linear target function synthesizes the spectrum and tristimulus discrepancy between the sample and match. The degree of confidence in the optimum solution is significantly heightened because the final output is always the concentration at a minimum of F. This effectively avoids a large deviation that appears frequently in Allen's algorithm. Besides, the value of F reflects metamerism in certain aspects.

This color match method can be applied to match arbitrary colorants, thus enlarging the application of computer color matching.

Introduction of Hardware and Software System

For a CCM system, it should be combined with the optical and computer system. We have researched a CCM system and has used in factory for two years. There are excellent measuring reliability and fast speed of color matching in practice.

CCD is the core of this spectrometer, the light power of the sample is very soft after that has been separated by the optical system and light diaphragm. We have used high sensitivity CCD (TCD142D) to bring about the high speed in electronic scanning, data processing and data transmission. The performance data of TCD142D are:

The number of light sensor: 2048
Range of spectrum: 300 ~ 900 nm
Sensitivity: 6 V/lx.s
Size of light sensor: 14 µm × 14µm

The software includes color measuring, color matching, data-base manager, recipe printer and other parts. We have designed many special functions to apply in factory in China that are different from CCM in the world, and all the menus are Chinese. The hardware and software is shown in Figure 1 to Figure 3:

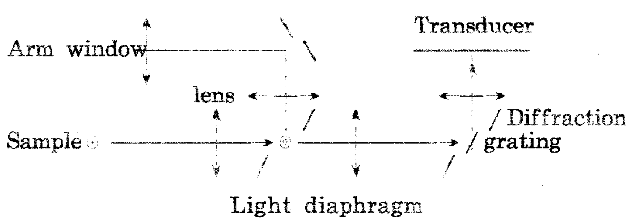

Figure 1. Optical structure of spectrometer

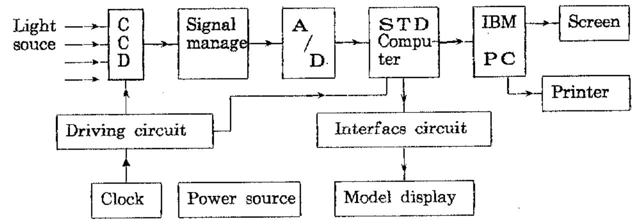

Figure 2. Circuit design of spectrometer

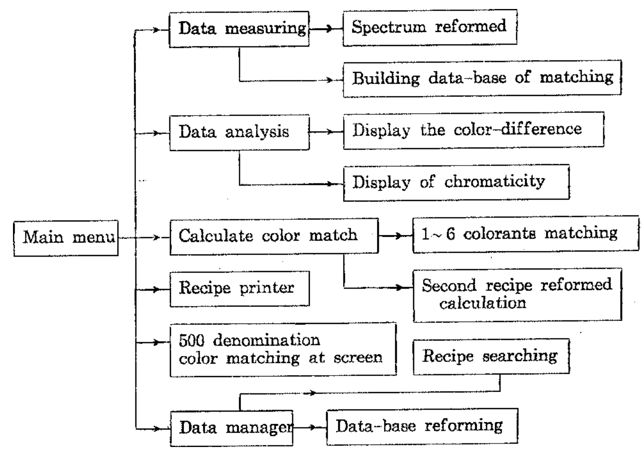

Figure 3. Software of our CCM system

Conclusions

Because of the length of the article, we can't introduce our CCM system in detail. We have done a lot of experiments at our CCM since 1990, the results have shown that the success rate of the first dyeing is 81%, second dyeing is 93% for the textile (color-difference is less 1.5 unit of CIE 1976 LAB).

References

1. E. Allen , "Basic Equations Used in Computer Color Matching" *J. Opt. Soc. Am.,* **10**, 1966.
2. Hua Zeng, Fengxiang Bai, "New Algorithm for Optimization of Computer Color Matching" *Optical Engineering*. V**32**, Number 8, August 1993. pp. 1815-1818.