2003년도 대한전자공학회 하계종합학술대회 제26권 제1호

퍼지 추론에 기반한 직물 염료 생산공정의 디지털 색상관리

장경원, 강진현, 황재명, 안태천
원광대학교 전기전자 및 정보공학부

Fuzzy Inference based Digital Color Management of Textile Dye Manufacturing

Kyungwon Jang, Jinhyun Kang, Jaemyoung Hwang, Taechon Ahn
Electrical Electronic and Information Engineering, Wonkwang University
E-mail : : tcahn@wonkwang.ac.kr

Abstract

In this paper, instead of conventional color management method that using spectrum analysis, a simplified color management scheme is proposed that is low-cost required method to reproduce the visual color perception of human. Proposed scheme uses computer color scanner to obtain a bit map image from dyed original color sample, and conducts pixel analysis by image histogram. From obtained image histogram, extract the color and RGB value from histogram that shows dominant pixel distribution of the sample image.

I. Introduction

A dye process of textile industry is important part that finally gives required quality to the textile material. In the practical dye manufacturing process, color management falls into two categories. First one is color management with an expert knowledge of colorist, the other one is computer aided way.

In this paper, instead of conventional color measurement method that using spectrum analysis, a simplified new color management scheme is proposed that using visual perception of human by the three stimulation of light. Proposed measurement scheme uses computer color scanner to obtain a bit map image from dyed original color sample, and conducts pixel analysis by image histogram. From obtained image histogram, sort the histograms from the biggest histogram to lowest in the order of the number of pixels. After sorting, extract the color and RGB value from biggest histogram that means dominant pixel distribution of the sample image. To obtain the color recipe, construct RGB color model for dyestuff manufacturing with intelligent algorithm. Constructed color model can minimizes additional experiments to obtain more color and produce the color recipe information from basic data.

II. Colors, Color Space and Color Perception

2.1 Color, Color Space

Figure 1 is RGB color space consist of three primary color of light that is red, green and blue. As shown in figure 1, all colors normalized in between 0 and 1. Black is located at origin. Red, green and blue is placed at the end of axis respectively. In case of 8bit color, color is normalized in between 0 and 255 per each channel. Therefore, representational colors of the 24bit graphics system are total 16,777,216 that have 8bit color per channel. Hence, red color that placed (1,0,0) color in figure 1 model corresponded to (255, 0, 0) in the 24bit graphics system [2]. In this paper, RGB color space (or model) is employed for the color management because color information of dyestuff is managed under computer graphics system.

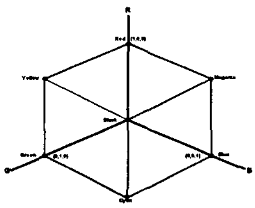


Fig. 1. RGB color space

2.2 Color Management for Dyestuff Manufacturing

General dye manufacturing process consist of the color measuring, reproduction and color matching step as shown in figure 2. Customers' original color sample is measured in the first step, and reproduces dye with measured color information in second step. After that, compare the color of reproduced dye with original color sample. If color difference satisfies a certain threshold, then produce dye. And if reproduced color does not match with original sample, repeat reproducing and matching sequence until threshold satisfied. In the practical process, dye manufacturing in figure 2 is divided into two categories by color management method that one is color management by colorists' expert knowledge without measurement and computational devices, the other way uses elaborate measurement device, experiment system and computer.

First management way uses experiential knowledge without a certain measurement devices. On the other hand, the second way that adopted in most of the large-scale plant uses spectral reflectance distribution of original color sample that is obtained from the spectrophotometer. Therefore, objective and precise color management is possible.

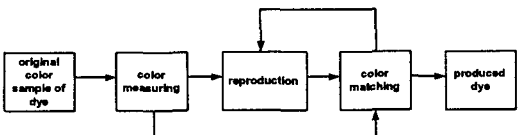


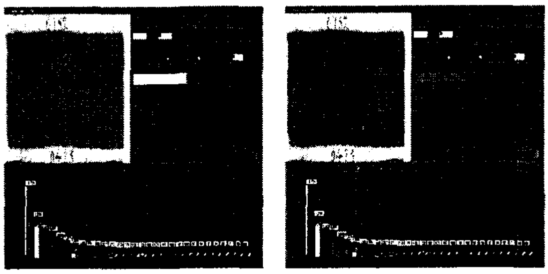
Fig. 2. General color management paradigm

III. Proposed Digital Color Management for Dyestuff Manufacturing

3.1 Color Measurements and Analysis with Image Histogram

Image processing operations can be sorted five categories that consist of enhancement, restoration, analysis, compression and synthesis. In the Image processing, image histogram is well known as representative method of image enhancement. Also Image histogram is a useful tool that shows the intensity profile of an image and gives detail information of the image composition about the contrast and intensity distribution of an image [2,3].

In this paper, we analysis color of pixel instead of pixel intensities and shows pixel distribution of each colors in the sample image to extract dominant color. Figure 3 is GUI (Graphical User Interface) of the proposed measuring scheme. After sample is imaged, select a certain area to be analyzed. If area is selected, this interface shows color histogram of pixel distribution and color information of the selected histogram. GUI in figure 3 is demonstration of proposed scheme that implemented by Delphi.



(a) (b)

Fig. 3. General color management paradigm

IV. RGB Color Model Design for Dye Manufacturing

4.1 Intelligent Model for Dye Manufacturing Process

RGB data in table 1 is extracted from dyes that used in practical dye manufacturing process. Upper row indicates names of 8 dyes that consist of 2 yellow dyes, 3 red dyes and 3 blue dyes. And Columns shows RGB values per depth that corresponds each dye on row

Table1. RGB data of sample color

No.& Depth (%)	R G B	Yellow 5GN	Yellow RXL	Red 10B	Red B	Red F-3GL	Blue G	Blue 5GM	Blue 6B
1 (0.01)	R	254	251	251	253	254	191	209	202
	G	253	240	234	221	225	224	240	212
	B	220	212	231	228	221	239	245	242
2 (0.05)	R	255	253	243	252	254	117	158	146
	G	254	240	194	170	181	175	215	159
	B	183	172	226	205	174	236	243	241

3 (0.1)	R	255	254	240	251	254	83	130	120
	G	254	233	166	140	159	148	195	129
	B	150	131	218	186	148	226	235	235
4 (0.2)	R	255	254	231	250	255	42	100	90
	G	254	218	129	116	138	123	171	97
	B	118	93	198	167	119	214	226	220
5 (0.5)	R	255	254	214	243	254	1	38	35
	G	254	202	89	64	112	73	131	34
	B	0	40	167	128	59	180	201	192
6 (1.0)	R	255	253	198	236	255	0	18	17
	G	253	181	43	33	92	46	107	8
	B	0	7	142	105	18	157	179	168
7 (1.5)	R	255	251	188	231	254	1	14	13
	G	252	164	26	22	81	39	92	4
	B	0	0	128	91	8	144	166	155
8 (2.5)	R	255	248	174	226	253	7	16	15
	G	249	147	8	14	68	29	75	4
	B	0	0	108	77	7	123	149	137

ANFIS is functionally equals with fuzzy inference system and represent fuzzy inference system with neural network structure. Basic architecture of ANFIS that equivalent with 2 input sugeno fuzzy model and learning procedure is shown in figure 4 and table 1, respectively [5].

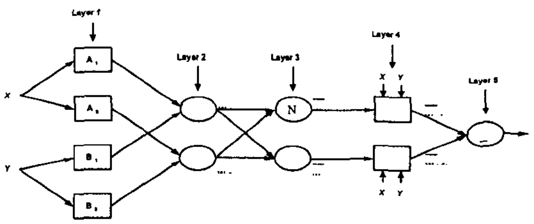


Fig. 4. ANFIS Architecture

ANFIS model for RGB color data is designed as a single input single output structure. Input variable is depth of dye that distributed within 0% to 2.5% and output is each R (red), G (Green), and B (Blue) Value in table 1. Performance of this model will be evaluated with a mean square of error. PI (Performance index) of model is defined as follows.

$$PI = \frac{1}{m}\sum (y - \hat{y})^2 \qquad (1)$$

Where, m is the number of output, y stands original output and $\hat{y}$ is the model output. The number of test data is 499 that generated from uniform division (0.005% interval) of input variables. Bell shaped membership function is employed and rule set is defined as follows [5]

$$\mu_A(x) = \frac{1}{1 + \left|\frac{x - c_i}{a_i}\right|^{2b}} \qquad (2)$$

Where, $\{a_i, b_i, c_i\}$ is the parameter set, As the values of these parameters change, the bell-shaped function varies accordingly, thus exhibiting various forms membership functions for fuzzy set.

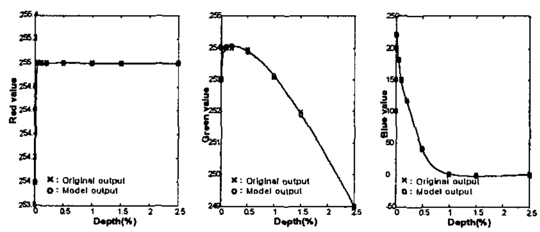
$$R^1 = \text{If } x \text{ is } A_1, \text{Then } Y = a_{01} + a_{11}x \qquad (3)$$
$$R^2 = \text{If } x \text{ is } A_2, \text{Then } Y = a_{02} + a_{12}x$$

Simulation of ANFIS model is performed with 500 epochs. Bell shaped function is employed for premise membership function, and first order polynomial is used in this simulation that defined in (1) and (2).

4.2 Simulation and Results

Figure 5 shows the simulation result of the RGB color ANFIS for the yellow 5gn color. In this simulation, just 8 data is given for the each color, so entire data is offered as learning data. For the test, total 499 data is used that is obtained from *uniform division of input range within 0% to 2.5%*. Performance index of RGB model is tabled in table 2.

Result of this simulation shows that we are able to estimate the additional dye recipe data when ready-made recipe data does not exist. With this result, we will introduce the proposed color management model for dyestuff manufacturing.



(a)Red (b)Green (c)Blue

Fig. 5. Simulation result of yellow 5GN

Table 2. Performance Index of ANFIS color model

	Yellow 5GN	Yellow RXL	Red B	Red 10B
R	5.4756e-006	8.1410-e004	2.8380e-002	5.4593e-003
G	5.8470e-003	3.4181-e001	8.8616e-002	1.9329e-006
B	3.9966e-002	1.203-e001	1.6901e-001	5.7917e-002
	Red F-3GL	Blue G	Blue 5GM	Blue 6B
R	4.2237e-002	1.4942e-002	3.5622e-001	3.3238e-001

G	3.9960e-003	1.1719e-001	2.3752e-001	1.0069e-001
G	5.1236e-002	8.0340e-006	1.1378e-002	5.0288e-002

V. Proposed Color Management for Dyestuff Manufacturing

5.1 Color Management Diagram

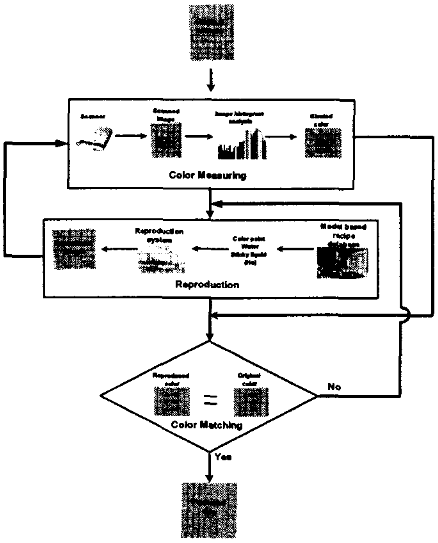
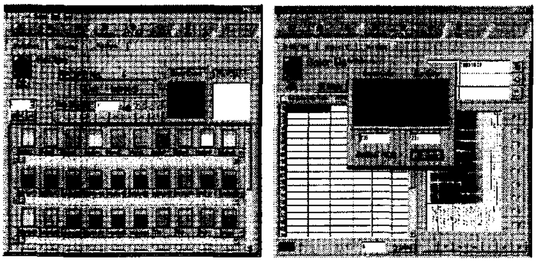


Fig. 6. Proposed color management paradigm

In the figure 6, the first sequence is color measuring with proposed histogram method. After this sequence, search the recipe database to get a corresponding recipe and reproduce the sample color with the obtain recipe. The recipe database is built with the basic recipe data and intelligent model that minimizes additional dye experiment to get a recipe data. After reproduction sequence, a reproduced color sample will be transmitted to the color measuring sequence for the color matching. Figure 7 shows recipe database and color matching interfaces that are implemented with a Delphi.



(a) Recipe database (b) Color matching

Fig. 7. GUI of the color matching and recipe database

VI. Conclusion

In this paper, instead of conventional color management method that using spectrum analysis, a simplified new color management scheme is proposed and its application programs are implemented. The backbone of the proposed scheme is color measurement with image histogram and intelligent model embedded recipe database. This recipe database is constructed for reliable dyestuff manufacturing with basic recipe data and intelligent algorithm. If specified color recipe does not exist in database, estimate the color recipe with the constructed intelligent model. This way minimizes additional experiment to obtain more color. And color matching is performed by Euclidian distance that compares RGB values of the original color with RGB value of the reproduced color. Our work is summarized in below.

1). Proposed color measurement scheme uses image histogram analysis of the pixel to select a dominant color.

2). RGB color model for dye manufacturing is implemented with intelligent algorithm. This model provides color recipe estimation capability information when a specified recipe does not exist in database.

3). Application programs are implemented for the proposed color management scheme

References

[1] E. J. Giorgianni and T. E. Madden, Digital Color Management Encoding Solution, Addison–Wesley, Inc., 1997.

[2] R. Crane, A Simplified approach to image processing: Classical and Modern Techniques in C, Prentice-Hall, New Jersey, 1997.

[3] G. A. Boxes, Digital Image Processing: Principles and Applications, John Wiley & Sons, Inc., 1994.

[4] E. Mizutani, H. Takaki and D. M. Auslander, "A Cooperative System based on Soft Computing Methods to Realize Higher Precision of Computer Color Prediction ", Proc. of Application and Science of Artificial Neural Networks, Part of SPIE's International Symposium on OE/Aerospace Sensing and Dual Use Photonics, pp. 303-314, 1995.

[5] J-S. R. Jang, "ANFIS: Adaptive-Network-based Fuzzy Inference Systems", IEEE Trans. on System, Man and Cybernetics, vol. 23. no. 3, pp. 665-685, 1993.