Estimation of Color and Reflectance Behaviors of Cross-Section of Fibers Using Neuro-Fuzzy Technique

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ABSTRACT

Reflectance factors and the lightness (L*) of the fibres are different in their cross-sectional and longitudinal directions and the mentioned values are higher for longitudinal directions surface. A neuro-fuzzy system was designed to relate the color of fibres in the mentioned directions. Results showed an excellent prediction with neuro-fuzzy technique in comparison to classical Kubelka-Munk method.

1. INTRODUCTION

The spectral and color behaviors of fibers are considerably different in longitudinal and cross section directions[1]. Fibers in loose structure or yarn form are normally presented to the windows of measurement instruments in their longitudinal direction without any consideration to its final applications. In color matching aspect, matching of fibers in their longitudinal direction, which is more popular in instrumental as well as visual color assessment, does not necessarily lead to an acceptable result in their cross-sectional direction. In handmade carpet as well as in the machinery type, where the cross-sections of fibers are faced to the observer, the color of cross-section is more important than the color in longitudinal direction. Some reports have been published to describe a relationship between the reflectance values of fibers (or yarns) in the mentioned directions[1-2]. The simplest relation was introduced by Bernard and co-workers showed in Equation 1[2].

$$\alpha = \frac{\left(\frac{K}{S}\right)_{CS}}{\left(\frac{K}{S}\right)_{YS}} = \frac{S_{YS}}{S_{CS}} \qquad (1)$$

In fact the classical $\frac{K}{S}$ functions of the reflectance values are applied to convert the values from one direction to the other one showed by α. The subscribe CS and YS refer to the cross-section and longitudinal directions respectively, and K and S show the absorption and scattering coefficients.

This paper presents a new method for prediction of the reflectance as well as the color of fiber in its cross-section from data obtained from longitudinal direction using neuro-fuzzy technique. Results are compared with classical Kubelka-Munk method.

2. METHOD

Semi dull as well as bright acrylic fibers with different finesses were dyed with suitable cationic dyes in different hues and depths. They were oriented to their longitudinal direction before introducing to the reflectance spectrophotometer for measurement, by short combing[3].

Two different fuzzy inference system (FIS), fuzzy IF/THEN rule and fuzzy reasoning were applied to convert the reflectance values as well as the color coordinates in the mentioned directions[4]. In reflection mode, an ANFIS with four inputs, 81 IF-THEN rules and one output was used, showed in Figure 1. Three Gaussian shape membership functions were also proposed.

In order to convert the colors in mentioned directions, three separate ANFIS were applied for CIELAB color coordinates (L^*, a^* and b^*). 27 IF-THEN rule again with three Gaussian shape membership functions were used. Figure 2 shows the applied neuro-fuzzy system for the color conversion

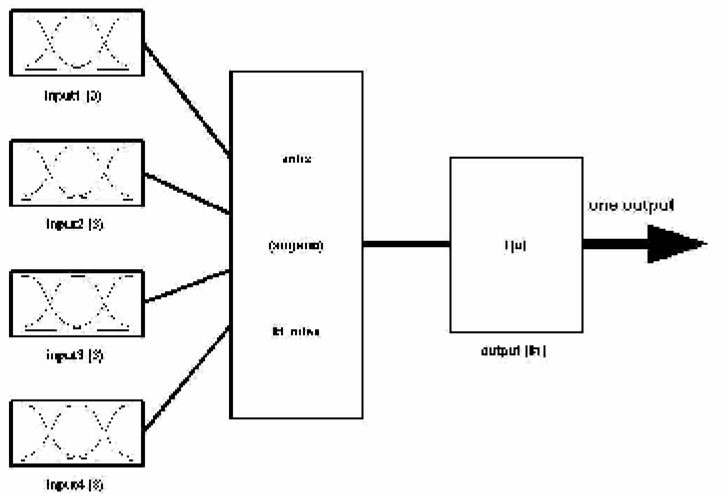

Figure 1: ANFIS structures used for calculation cross-sectional behaviors from reflectance of longitudinal direction.

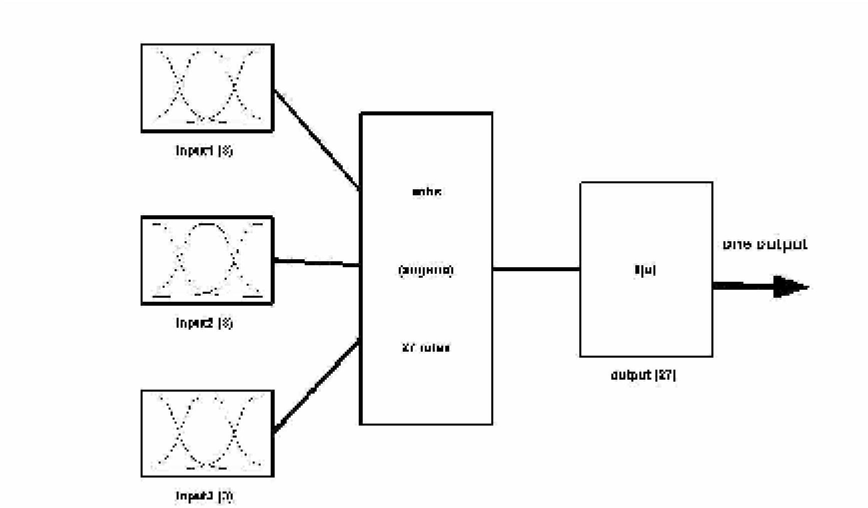

Figure 2: ANFIS structures used for calculation cross-sectional color from the tristimulus values of longitudinal direction.

3. RESULTS AND DISCUSSIONS

Results of prediction of the reflectance as well as the tristimulus values of the cross sections of different types of acrylic fibers from the reflectance and the tristimulus values of the longitudinal direction are listed in Table 1. The mean, minimum and maximum color difference values under D_{65} and 1964 standard observer between the measured (actual) and the predicted values by fuzzy techniques as well as classical method are shown in Table 1. In fact, in order to evaluate the outcomes from neuro-fuzzy method, the results are compared with conventional method, suggested by Bernard and co-workers[2] using Kubelka-Munk model.

As Table 1 shows, a significant improvement achieved by applying of neuro-fuzzy method in converting of the longitudinal data to the cross-sectional output. The best results were achieved by using neuro-fuzzy for tristimulus values while, the classical method led to the worst output. Table 1 indicates that the minimum color difference value for the Bernard *et al* method is higher than the maximum color difference which is resulted from neuro-fussy technique in the color mode.

Table 1. Color difference between measured and calculated cross-sectional color of acrylic fiber

Sample #	Physical characteristics of samples				Using neuro-fuzzy and R_λ	Using neuro-fuzzy and L*a*b*	Using K-M
	Luster	Fines (denier)	hue	depth			
1	Semi-dull	15	Virgin	----	0.301	0.027	7.000
2	Semi-dull	15	Blue-black	Dark	1.236	0.107	2.775
3	Semi-dull	15	Blue-black	Light	2.58	0.152	2.743
4	Semi-dull	15	Blue	Dark	3.086	0.128	2.756
5	Semi-dull	15	Blue	Light	1.483	0.152	3.721
6	Semi-dull	15	Red	Dark	2.68	0.118	1.985
7	Semi-dull	15	Red	Light	.984	0.122	4.539
8	Semi-dull	15	Yellow	Dark	1.917	0.119	9.142
9	Semi-dull	15	Yellow	Light	0.684	0.204	12.105
10	Semi-dull	10	Virgin	------	0.078	0.033	3.384
11	Semi-dull	10	Blue-black	Dark	2.605	0.101	1.325
12	Semi-dull	10	Blue-black	Light	2.709	0.178	3.570
13	Semi-dull	10	Blue	Dark	2.389	0.132	1.194
14	Semi-dull	10	Blue	Light	1.803	0.154	4.320
15	Semi-dull	10	Red	Dark	1.267	0.118	1.460
16	Semi-dull	10	Red	Light	2.628	0.135	2.503
17	Semi-dull	10	Yellow	Dark	1.769	0.131	8.568
18	Semi-dull	10	Yellow	Light	0.544	0.196	5.552
19	Semi-dull	7	Virgin	------	0.438	0.031	6.177
20	Semi-dull	7	Blue-black	Dark	1.912	0.11	1.398
21	Semi-dull	7	Blue-black	Light	3.374	0.198	2.873
22	Semi-dull	7	Blue	Dark	4.435	0.161	1.884
23	Semi-dull	7	Blue	Light	2.797	0.201	3.575
24	Semi-dull	7	Red	Dark	2.596	0.134	1.703
25	Semi-dull	7	Red	Light	3.301	0.218	3.333
26	Semi-dull	7	Yellow	Dark	1.213	0.132	3.226
27	Semi-dull	7	Yellow	Light	3.325	0.173	8.571
28	bright	15	Virgin	------	2.132	0.104	5.603
29	bright	15	Blue-black	Dark	0.544	0.120	0.0953
30	bright	15	Blue-black	Light	2.38	0.224	4.5050
31	bright	7	Virgin	------	2.364	0.102	5.2350
32	bright	7	Blue-black	Dark	0.326	0.117	3.8060
33	bright	7	Blue-black	Light	3.854	0.211	6.8970
Average					2.022	0.141	4.3210
Maximum					4.435	0.311	12.10
minimum					0.078	0.027	0.953

CONCLUSIONS

It was tried to find a relationship between the reflectance and color of cross-sectional of fibers from their longitudinal reflectance value and color coordinates. For this purpose a neuro-fuzzy technique was employed and compared with classical method which employs the Kubelka-Munk method. The average color difference in Kubelka-Munk method was significantly higher in comparison with suggested neuro-fussy technique. The best result was obtained by using neuro-fuzzy when applying the CIELAB color coordinates.

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