FUZZY CLASSIFICATION METHOD OF COLOR-RENDERING QUALITY OF LIGHT SOURCE

Chen Zhenpei Li Jitao
(Sichuan University)
Li Zuoyong
(Chengdu Meteorological Institute)
Chengdu, Sichuan, P. R. China

ABSTRACT: In this paper, a fuzzy classification method of color-rendering quality of light source is presented, based on the membership function of classification grade of color-rendering quality of light source.

Keywords: Application of fuzzy sets; Colorimetry

1. INTRODUCTION

To judge the quality of a light source, on the one hand, depends on th rationality of its technical index of economy, on the other hand, depend on its visual effect. The color-rendering properties of light source is t important index of judging vision quality of light source. In general , color-rendering properties of light source is represented with a color-rendering index. The color-rendering index of light source is a measure of the coincidence of colours of two objects that are shown when the objects are illuminated by light source to be termined and reference light source respectively. The color-rendering index of light source for a colo sample is defined as special color-rendering index.[*1]

$$R_i = 100-4.6\Delta E \; . \qquad (1)$$

Here, E is the colour difference of colour samples when the samples are illuminated by the two light sources.

The mean color-rendering index of light source for particular colour samples is defined as general color-rendering index

$$R_a = \frac{1}{8}\sum_{i=1}^{8} R_i \qquad (2)$$

The more the general color-rendering index of light source is, the better the color-rendering properties of light source, in general, the general color-rendering index of light source is divided into three regions. It is represented in table 1.

Table 1 Classification of Color-rendering Quality of Light Source

the general color-rendering index	classification of color-rendering
100 — 75	superior
75 —50	ordinary
50 — 0	inferior

It is not suitable to take color-rendering indexs 75 and 50 as demarcation of color-rendering grade of light source. Because classification grade "superior", "ordinary", and "inferior" of color-rendering quality are fuzzy conception. There are not apparent demarcation line between them. If the difference of color-rendering index is number one in the demarcation, then one kind will transform to another kind. The method of classification is not suitable. Therefore it is the best described way applying fuzzy conception.

This paper designs membership function $\mu_1(R)$ of "superiority" and $\mu_2(R)$ of "inferior" of classification grades for color-rendering quality of light source. For an abtrary light source, we can calculate the membership degree of its color-rendering index for $\mu_1(R)$ and $\mu_2(R)$, and then based on the rule of fuzzy operation, the membership degree of color-rendering index for "ordinary" is calculated. Further if a threshold α_0 is given out, we can make the fine classification for color-rendering index.

2. THE MATHEMATICAL MODEL AND METHOD OF CLASSIFICATION OF COLOR-RENDERING QUALITY OF LIGHT SOURCE

Based on the character of this question, the membership function of "superiority" and "inferior" of color-rendering quality of light source are designed as follow respectively*2

$$\mu_1(R) = \begin{cases} 0 & \text{if } R \leqslant 65 \\ \dfrac{1}{1 + \left[\frac{1}{5}(R - 65)\right]^{-2}} & \text{if } R > 65 \end{cases} \tag{3}$$

$$\mu_2(R) = \begin{cases} 1 & \text{if } R < 40 \\ \dfrac{1}{1 + \left[\frac{1}{10}(R - 40)\right]^{3}} & \text{if } R \geqslant 40 \end{cases} \tag{4}$$

The plots of function are shown in fig. 1.

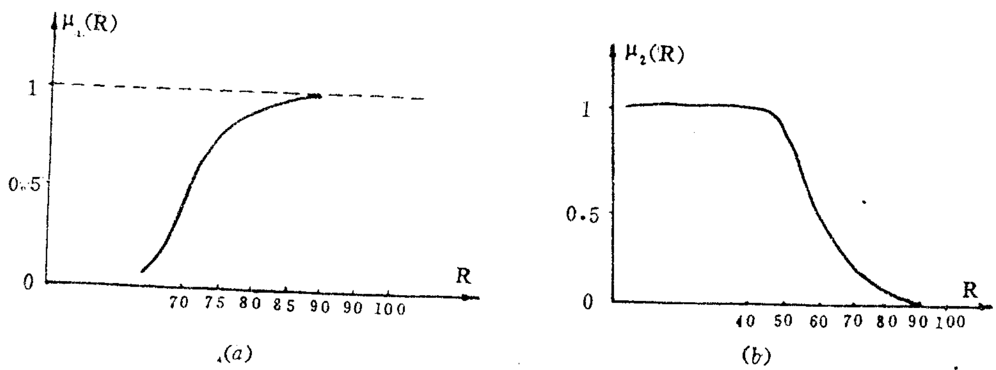

Fig. 1

According to the rule of operation in fuzzy sets, the "ordinary" membership function of color-rendering quality of light source is taken as

$$\mu_3(R) = \left[1 - \mu_1(R)\right] \wedge \left[1 - \mu_2(R)\right] \tag{5}$$

When color-rendering indexs are selected some numerical value, the membership degrees of color-rendering quality of light source, which belong to "superiority" , "inferior" and "ordinary" grades by formula

(3), (4), (5), and classification are shown in table2.

Table 2

Color-rendering index	$\mu_1(R)$	$\mu_2(R)$	$\mu_3(R)$	Fuzzy Classification
30	0	1	0	inferior
35	0	1	0	inferior
40	0	1	0	inferior
45	0	0.89	0.11	inferior
50	0	0.50	0.50	inferior or ordinary
55	0	0.23	0.77	ordinary
60	0	0.11	0.89	ordinary
65	0	0.06	0.94	ordinary
70	0.50	0.04	0.50	ordinary or superior
75	0.80	0.02	0.20	superior
80	0.90	0.02	0.10	superior
85	0.94	0.01	0.06	superior
90	0.96	0.01	0.04	superior
95	0.97	0	0.03	superior
100	0.98	0	0.02	superior

If we want to distinguish color-rendering quality into "very superior", "superior" and "more superior" or "inferior", "more inferior", " very" inferior", we can design membership function as follow; $\mu_1^2(R)$, $\mu_1^3(R)$; $\mu_2^2(R)$, $\mu_2^3(R)$; $\mu_3^2(R)$, $\mu_3^3(R)$ and judged for designated threshold value α_0 according to the rule in table 3.

For example, if color-rendering index R = 80, according to formula (3), $\mu_1(80) = 0.90$, it belongs to "superior" grade, according to table 2; If we want to judge its extent furtherly , which appertains to "superior" grade, we can give a designated threshold $\alpha_0 = 0.75$.

Table 3

membership function	$U_1(R)$	$U_1^2(R)$	$U_1^3(R)$	$U_2(R)$
threshold value	$\geq \alpha_0$	$\geq \alpha_0$	$\geq \alpha_0$	$\geq \alpha_0$
classification	more superior	superior	very superior	more inferior

$U_2^2(R)$	$U_2^3(R)$	$U_3(R)$	$U_3^2(R)$	$U_3^3(R)$
$\geq \alpha_0$	$\geq \alpha_0$	$\geq \alpha_1$	$\geq \alpha_0$	$\geq \alpha_0$
inferior	very inferior	ordinary	more ordinary	very ordinary

Because $\mu_1^2(80) = 0.81 > 0.75 = \alpha_0$, whereas $\mu_1^3(80) = 0.73 < 0.75 = \alpha_0$ so when shreshold value $\alpha_0 = 0.75$, the color-rendering quality of color-index R = 80 belongs to "superior" only, not "very superior".

If R = 90, then $\mu_1(90) = 0.96$, $\mu_1^2(90) = 0.92 > 0.75 = \alpha_0$, $\mu_1^3(90) = 0.88 > 0.75 = \alpha_0$. It will be seen that the color-rendering quality of R = 90 belongs to "very superior" for threshold $\alpha_0 = 0.75$.

3. COMPARARISON AND CONCLUSION

Classical classification method of color-rendering properties of light source is absolute, while the fuzzy classification method of color-rendering properties of light source has no evident demarcation, it has a shift border. But it has a maximum of certain classification grade for a certain color-rendering index. For example, when color-rendering index R = 80, it appertains to "superior" absolutely in classifical classification, while it appertains to "superior" too , according to fuzzy classification method, but the membership degree of "superior" is 0.90 only, the membership degree of "ordinary" and "inferior" are also 0.1 and 0.01 respectively. Namely its "superior" is relative. Therefore, this classification method is reasonable and natural.

Furthermore, if a threshold value α_0 is given out, we can further determinate a fine classification for color-rendering index. Certainly, according to different selection of threshold value α_0, the classification is different for same color-rendering index. At the same time, according to the different selection of membership function of "superior" and "inferior", the membership degree of same color-rendering index for certain classification can be changed with this method.

Just this reason, when color-rendering of light source is classified according to this method, the subjective factor of person is considered.

REFERENCE

*1. Jing Qicheng et. COLORIMETRY, publishing house of science & technology, 1979, 265-267.

*2. Wang Peizhuang(汪培庄) FUZZY SETS AND ITS APPLICATION, Publishing House of Science & Technology in Shanghai, 1983, 21-26.