Comparative analysis of Visual Field 2°or 10°in Printing Color Measuring

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Abstract

Visual field is an important parameter in color measuring, but in national standard it is not uniform for the visual field selection. This paper analyzes the visual physiological characteristic of 2 and 10 degree visual fields. The color difference of one color in different visual field and is calculated. Also color difference of a pair of print colors is calculated. The result shows that the selection of visual fields can affect the evaluation evidently. Therefore 2-deg visual field is recommended in printing color measuring.

Key words：*Visual field；Printing color；Color difference；Color measuring*

Introduction

Visual field is the total area in which objects can be seen in the peripheral vision while the eye is focused on a central point [1]. There are 2-deg and 10-deg in color measuring. In Chinese national standards GB/T 7705-87(The offset lithographic prints for decorating), GB/T 7706-87(The relief prints for decorating)、GB/T 7707-87(The intaglio prints for decorating), the visual field adopted in color difference measuring is 10-deg. But in GB/T 17934.1-1999（Graphic technology-Process control for the manufacture of halftone colour separations, proof and production prints—Part 1: Parameters and measurement methods）which is equivalent to ISO 12647-1:1996 quoted from ISO 13655, the color measurement condition is that the geometrical condition is 45/0 or 0/45, the illuminant is D50, and CIE1931 standard observer is adopted to calculate the tristimulus values. That is to say the 2-deg visual field was adopted. In Chinese Industry Standard CY/T 3-1999(Standard illuminating and observing conditions for colour evaluation) there is no prescription which visual field should be adopted in printing color measurement, while in CY/T 31-1999(Graphic technology Colour and transparency of ink sets for four colour printing-Part 1: Sheet-fed and heat-set web offset lithographic printing) which is equivalent to ISO 2846-1:1997 specifies definitely that CIE1931 standard observer is used in printing color measurement, which is same to GB/T 17934.1-1999.

Physiologic Characteristic of visual fields

There are cones and rods on the retina of the eyes. Rods serve vision at low luminance levels while cones serve vision at higher luminance levels. Color vision is the function of the cones and rods can't get color information. Therefore it is important for printing industry to research cones. Cones are distributed on the fovea of the retina. Its density is decreased from fovea to circumference and disappeared at the ora serrata. About 7 million cones are centralized in 2-deg field of view and cones and tones coexist out of 2-deg field of view, showed as Fig.1.

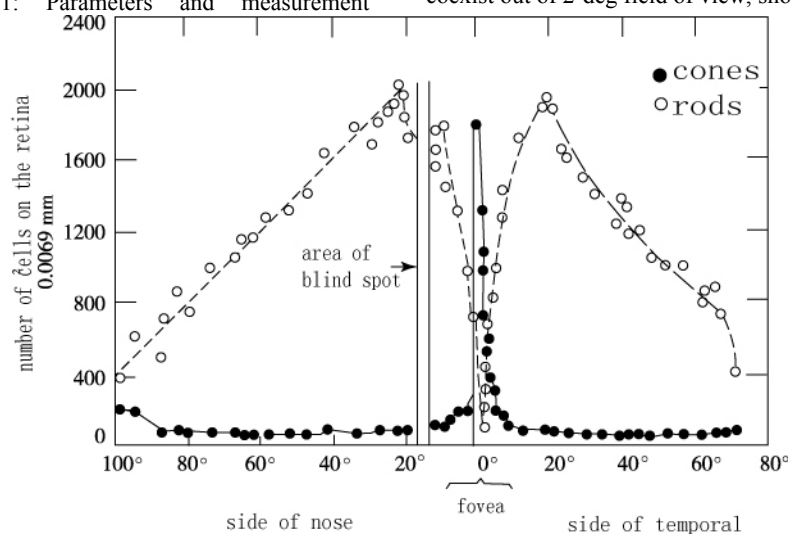

Fig.1 Distribution of cones and rods on retina[2]

The macula exits in the retina, and serves to protect fovea from intense exposures to short-wavelength energy which can lead color to change. The density of the macula pigment is mixable at fovea and decreases to the circumference. This is the reason why the color difference exits when large-area and small-area color are viewed. In laboratory Maxwell spot will occur when the visual field is more than 4 degrees. Different results can be got when color are viewed at different visual fields. When large visual field

is used the Maxwell spot should not be concentrated. Therefore when high-definition and high-resolution 2-deg should be adopted in order to the object image can be formed in fovea.

Different observers at different visual field

CIE1931XYZ standard Colorimetric observer at 2-deg visual field was recommended in 1931 by International Commission on Illumination, and CIE1964 supplement Colorimetric observer at 10-deg was recommended in 1964. Fig.2 shows the tristimulus curves of the two Colorimetric observers. Fig.3 shows the chromaticity difference at two visual fields. The two figures shows that with the visual field increased the capability of color vision is increased.

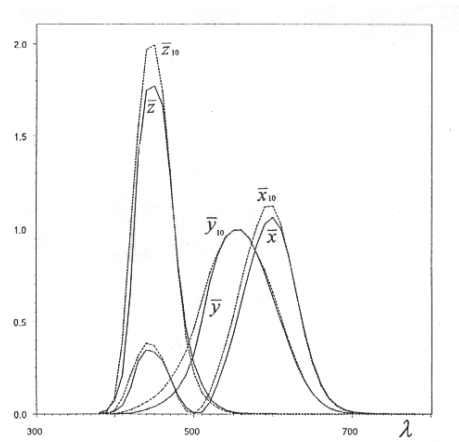

Fig.2 Standard Colorimetric Observer under 2°and 10°visual fields

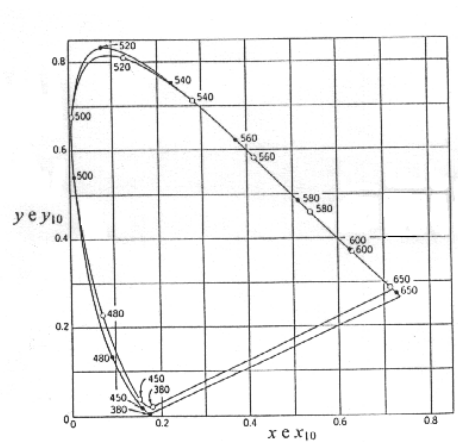

Fig.3 Chromaticity diagram under 2°and 10°visual fields

Effect of visual field to color evaluation

Comparison of same color between different visual fields

The spectral reflectance of a color is shown in Fig.4. Its tristimulus value can be calculated according to GB/T 3979-1997(Methods of measuring the color of materials):

$$\begin{cases} X = K\int_{\lambda} S(\lambda)R(\lambda)\bar{x}(\lambda)d\lambda \\ Y = K\int_{\lambda} S(\lambda)R(\lambda)\bar{y}(\lambda)d\lambda \\ Z = K\int_{\lambda} S(\lambda)R(\lambda)\bar{z}(\lambda)d\lambda \end{cases} \quad (1)$$

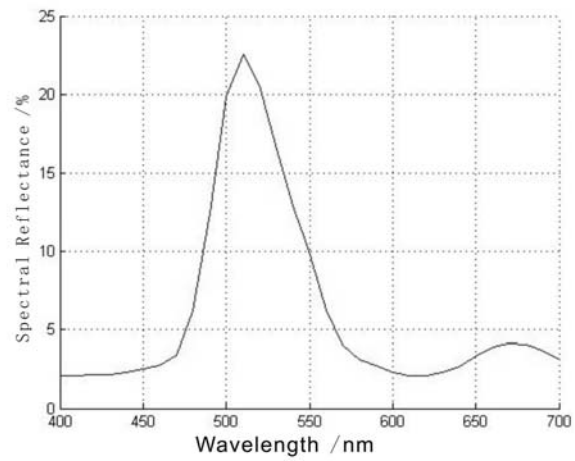

Fig.4 Spectral reflectance curve of a color

Tristimulus value X10Y10Z10 are calculated using the following equations：

$$\begin{cases} X_{10} = K_{10}\int_{\lambda} S(\lambda)R(\lambda)\bar{x}_{10}(\lambda)d\lambda \\ Y_{10} = K_{10}\int_{\lambda} S(\lambda)R(\lambda)\bar{y}_{10}(\lambda)d\lambda \\ Z_{10} = K_{10}\int_{\lambda} S(\lambda)R(\lambda)\bar{z}_{10}(\lambda)d\lambda \end{cases} \quad (2)$$

Where R(λ)——spectral reflectance factors;

K——coefficient of naturalization,

$$K = 100\Big/\int_{\lambda} S(\lambda)\cdot\bar{y}(\lambda)\cdot d\lambda;$$

K10——coefficient of naturalization,

$$K_{10} = 100\Big/\int_{\lambda} S(\lambda)\cdot\bar{y}(\lambda)_{10}\cdot d\lambda;$$

S(λ)——relative spectral power distribution of standard illuminant;

λ——wavelength, 380～780nm。

Tristimulus value X, Y, Z and L*, a*, b* are obtained under D65 illuminant and 2-deg and 10-deg at 10 nm wavelength interval, shown in Tab.1.

Tab.1 Tristimulus value X, Y, Z and L^*, a^*, b^* under different visual fields

Visual field	Tristimulus value					
	X	Y	Z	L^*	a^*	b^*
2°	3.80	9.13	4.64	36.42	-50.87	22.89
0°	4.07	9.23	4.12	36.24	-54.19	20.21

Color difference formula is shown in Equ.3.

$$\Delta E^*_{ab} = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \quad (3)$$

The color difference of the same color under different visual fields is 4.26. Consequently the difference is obviously at under different visual fields.

Comparison of different colors

Fig.5 shows the spectral reflectance of original color and printing duplicated color.

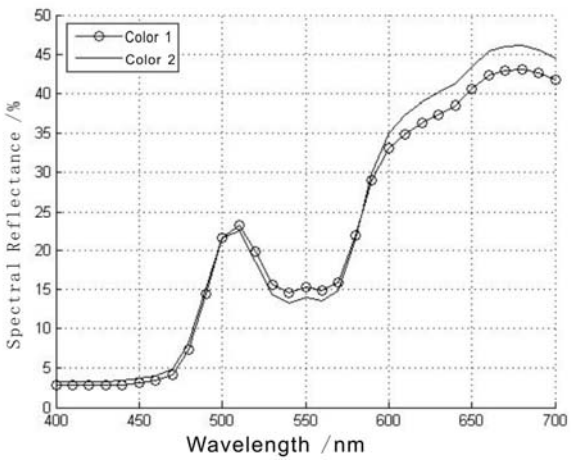

Fig.5 Spectral reflectance curve of a pair of colors

The color difference between the two colors is 4.8 under D65 illuminant and 2-deg visual field, while 5.5 under 10-deg visual field. The L* is more than 50 of this pair of colors. According to the judgment rule of prints quality [4], color difference of fine prints should be less than 5, while that of ordinary print should be less than 6. If 2-deg visual field is selected the print in Fig.5 is fine print, and is ordinary products if using 10-deg. Therefore when contracts are signed between printing enterprises and the clients the condition such as visual field used in color evaluation, illuminant etc al. should be defined in so many words.

Conclusion

Higher definition and higher resolution are required in printing industry, and so visual field should be same in printing color measurement otherwise the result may be different. Also other measuring condition should be defined. In order to be unified with international standards 2-deg visual fields is recommended.

Reference

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