Chapter 10
Parameter Optimization Experiment for Soft Proofing

Hongxia Zhou and Maohai Lin

Abstract Some experiments were designed to check the effects of monitor parameters such as color temperature, brightness, and gamma value on soft proofing. We have two illuminant levels D50 and D65, two brightness levels 100 and 120, and two gamma value levels 1.8 and 2.2 to be chosen in constructing *international color consortium* profiles (ICC profiles). Then, soft proofing simulation experiment was executed. Comparisons were made between the results of soft proofing and printer to obtain the optimum parameters. Results were evaluated by color difference analysis, individual component analysis of ΔL^*,Δa^*, and Δb^* values, and psychophysical experiments. Experiments show that the performance of soft proofing varies a lot with different parameters. And it can get a better performance with the appropriate parameters. At last, the optimal parameter combination was obtained.

Keywords ICC profile · Soft proofing · Color difference analysis · Psychophysical experiment

10.1 Introduction

Nowadays, soft proofing technology attracted the attentions by many professional researchers. It is necessary to improve the accuracy level of soft proofing. So that we can make sure the copy color presented by other media will stay close to the original. To solve this problem, some people is improving the parameters in the display manufacturing process or selecting the reasonable modulation of the display parameters such as color temperature, brightness, and gamma values. Experiments in the paper were carried out by the Eizo display. It has some steps such as checking

H. Zhou · M. Lin (✉)
School of Printing and Packing Engineering, Qilu University of Technology, 250353 Jinan, China
e-mail: imhlin@163.com

Y. Ouyang et al. (eds.), *Advanced Graphic Communications, Packaging Technology and Materials*, Lecture Notes in Electrical Engineering 369,
DOI 10.1007/978-981-10-0072-0_10

the differences among the appearances presented by the same display using different display parameters, analyzing the gap among appearances, and finding the optimal combination of parameters for Eizo display.

Color temperature represents the white point in display. Brightness of display represents the brightness of white point. Gamma value determines the contrast of image in monitor in every brightness level [1]. Besides an accurate display profile, there are accuracy that depends on the color management module and the specified white point (color temperature) [2]. Now, no agreed method of determination of profile accuracy was available. Color difference was executed for evaluation of different profiles made based on different parameters in one monitor.

10.2 Designs of Experiments

10.2.1 Equipment Used

Eizo EV2313W liquid crystal display (LCD), Dell host, eye-one pro of X-rite company, and Konica Minolta's digital printer. Ninety-nine color patches in *i1 profiler* software were selected as test target, as some experiments show that the differences in quality of ICC profile documents produced with 99 or 4096 color are small [4].

10.2.2 Experiment

10.2.2.1 Experiment Preparation

Make sure that setting indoor lighting, cleaning the display screen, giving display a stable state by warming up for 30 min. And restore the display factory settings, turn off the screen savers [3], and connect eye-one pro to computer.

Design experiment: Let the view on the screen be close to printing image, and it required color temperature of D50 or D65. It also had brightness of 100 and 120. The gamma values have a decisive influence on lightness shadow, and 1.8 and 2.2 is chosen with Dell host. Combine three kinds of parameters into eight groups (Table 10.1).

10.2.2.2 Steps of Experiment

(1) Creation of monitor profile: compared with *Profilemaker*, *i1profiler* produced profiles with higher accuracy [5], so *i1profiler* was used. Open the Advanced Options in *i1profiler*, and select the color management. Set parameters and

Table 10.1 Eight combinations of parameters in display setting

Group	Color temperature	Brightness	Gamma value
1	D50	100	1.8
2	D50	100	2.2
3	D50	120	1.8
4	D50	120	2.2
5	D65	100	1.8
6	D65	100	2.2
7	D65	120	1.8
8	D65	120	2.2

calibrate eye-one pro. Monitor profiles were created in *i1profiler* operation process. Twenty-four color patches coming from *Color Checker* were used to detect calibrated monitor.

(2) Creation of profile to printer: at first, keep the printer warm-up to stable point and connect the measuring instrument eye-one pro. Choose the color management button in *i1profiler* and set parameters in Advanced Options. Print IT8.7/3 target for measuring the data and use these data to create profile to printer.

(3) Implementations of soft proofing: at the beginning, keep the display on stable point in 30 min and set ICC profile to monitor. There are steps in the following text.
Step 1, Open *Photoshop*, we could find the setting option and select the Custom option in Edit option. Then, we might set the RGB color space as Adobe RGB (1998) and CMYK color space as U.S. Web Coated (SWOP) v2, and close the Color Management Policies option. Step 2, Open the color target. In View option, we might find the proof setup, select the Custom option, set the Device to Simulate option as the profile to printer, and set Rendering Intent option as Absolute Colorimetric. Step 3, Make the images full screen one by one in *Photoshop*. Comparisons were made about the views of images between printer and monitor.

(4) Experimental data: Every combination of parameters created a profile, and soft proofing was carried out in *Photoshop*. *Eye-one pro will be* used to measure the color patches presented on the Eizo monitor and will get the RGB values. Each patch should be measured 3 times and save the mean value. Taking into account the stability and effects of the sensitivity on monitor, black point should be measured eight times with 1-min interval and save the mean value.

10.2.2.3 The Analysis of Experimental Data

Every group of data measured from above experimental work by measuring instrument, was compared with the original data measured from paper subtract above experimental work. ΔE of the monitor patches and printer patches was

Table 10.2 Some analysis about ΔE in eight groups

Group	1	2	3	4	5	6	7	8
Avg	3.09	3.10	2.43	2.33	2.93	2.71	2.76	2.57
Var	1.92	1.83	1.51	1.54	1.47	1.20	1.90	1.81
Max	8.86	8.78	7.72	8.26	8.53	7.27	9.30	9.24
Min	0.48	0.66	0.53	0.44	1.05	0.68	0.48	0.76

calculated, which is recorded as $x_1, x_2, x_3 \ldots x_n$, based on the formula CIEDE2000. It is said that CIEDE2000 formula has the best result than other formula, such as CIELAB, CIE94, and CMC [6]. The calculation such as average of ΔE, variance of ΔE by Eq. 10.1, maximum of ΔE, and minimum of ΔE are shown in Table 10.2.

$$\text{Variance} = s^2 = \frac{(x_1 - M)^2 + (x_2 - M)^2 + (x_3 - M)^2 + \ldots + (x_n - M)^2}{n} \quad (10.1)$$

In Eq. 10.1, n is the number of color patches and M is the mean of ΔE.

According to the evaluation of ΔE from Table 10.1, the Group 4 has the lowest value of ΔE, and the Group 3 and Group 8 followed. The lowest variance value of ΔE is Group 6, and Group 5 and Group 4 followed. Taken together, the combination of parameters in Group 4, namely D50 on color temperature, 120 on luminance, and 2.2 on the gamma value has optimum effect in soft proofing. And Group 3, Group 6, and Group 8 followed.

Then, the analysis of each component value, namely ΔL^*, Δa^*, and Δb^*, was shown in Table 10.3. As there were more number of data in every group , we signaled the mean of original data as $\overline{\Delta L^*}$, $\overline{\Delta a^*}$, and $\overline{\Delta b^*}$ for simplification.

As shown in Table 10.3, the overall range of the variation of Δa^* values representing the D value (difference value) of the two groups with respect to red and green brightness value is higher than the range of variation of ΔL^* and Δb^* representing brightness values and yellow-blue value, respectively. The value of brightness was

Table 10.3 The average data and the variance data of $\overline{\Delta L^*}$, $\overline{\Delta a^*}$, and $\overline{\Delta b^*}$

Group	Avg			Var		
	$\overline{\Delta L^*}$	$\overline{\Delta a^*}$	$\overline{\Delta b^*}$	$\overline{\Delta L^*}$	$\overline{\Delta a^*}$	$\overline{\Delta b^*}$
1	−2.19	0.66	1.96	1.23	14.63	9.90
2	−2.28	0.89	1.92	1.12	15.66	8.51
3	1.29	−0.48	−2.05	1.01	11.97	5.25
4	1.22	−0.62	−1.67	1.01	12.63	4.75
5	2.05	−0.67	1.75	1.02	16.94	8.20
6	1.80	−0.68	1.50	0.98	17.69	7.45
7	1.24	−0.69	1.49	0.98	16.00	8.05
8	0.71	−0.73	1.52	1.07	16.31	8.55

floating small and had the good stability, the average of Δa^* values was relatively small, but was least centralized, overall had a big variance, and Δb^* values followed. From the numerical stability, we can select the optimum combination of parameter ΔL^*, the minimum variance, which explained that the difference value between the two data relatively was small changes. We can choose the minimum mean value from the eight groups of ΔL^* values as the best choice, and Group 8 had the minimum value in 8 groups data, followed by Group 4 and Group 7.

Since the variance of Δb^* values is greater than the variance of Δa^* values, the variance of Δb^* values is relatively stable on the second order; we selected the minimum value from the means of every Δb^* value as the optimum selection. The result is that the group 3 is the first and followed by the group 4 and group 5. At last, we had two methods to select the optimum parameter combination. It is received that the Group 5 combination of display parameters, namely D65 on the temperature, 100 on brightness, and 1.8 on the gamma value, is the optimum selection comprehensive of the above two methods.

At the end, ICC profiles had been loaded in the *Color Thinker pro v3.0.3* software. In that way, we can see the size of color gamut determined by the given ICC profile. According to the detection, some difference has been found that two ICC profiles made by two illuminant levels had the different sizes of color gamut. The ICC profile having D65 illuminant level had a bigger color gamut size than it having D50 illuminant level. But the profiles having different brightness levels and different gamma value levels had slight difference in color gamut size.

10.2.3 Psychophysical Experiments

Color science is developed from the development of study of psychophysical experiments and the study of human color vision characteristics. Evaluation of color reproduction is still based on the human visual effect-based assessment. Here, this paper had designed a psychophysical experiment for evaluating the result of the soft proofing color reproduction.

The design of test experiment for color reproduction is based on human visual effect: methods of observation and memory matching.

10.2.3.1 The Setting of the Environment

Keep the ambient lighting not too bright. Light box was placed on the side of display and let them kept side by side. Set the brightness of light box on the color temperature of D65. At first light box should be opened and preheated for 30 min, then put the print reproductions in the light box with its back against the light box's back wall to be observed. *Photoshop* software was started in Eizo display to carry out the soft proofing experiment, and open the image to be observed in Photoshop program.

10.2.3.2 Test Page

Choose pictures with skin colors and other colors, such as the black color representing accuracy of the neutral gray reproduction and some memory color, namely grass color, blue sky color, and so on.

10.2.3.3 Grading System

Divide the test into five grade levels. The first level has no color difference that sense is same to each color. The second level is feeling vaguely some color differences, but very weak. The third level is an acceptable color, and after careful observation, observers can see one or a few slight color difference. The fourth grade level has color differences which can be pointed out without a very careful observation.

10.2.3.4 Observation

Ten people were selected as observers; they are all accepted professional education. There were three test images such as color patch, skin color, and grasslands. Observers stood in front of the light box at a distance of 60 cm directly, forming two-degree field coverage. First observers stared light box in 1 min to suit the brightness. Then, observers looked at the prints placed in light box, then turned their eyes to Eizo monitor, and checked the images opened in the monitor. Then, evaluated the result and graded the view between the monitor and printer.

10.2.3.5 Calculation of Results

The formula for evaluation of ΔE between soft proofing and the printer toke the mean data as the result. Here, the Eq. 10.2 is given as follows:

$$A = (N_1 \times 1 + N_2 \times 2 + N_3 \times 3 + N_4 \times 4 + N_5 \times 5)/M \tag{10.2}$$

In Eq. 10.2, A was the average value and M was the times of observations. For one test color, N_1, N_2, N_3, N_4, N_5 represent the number of scores on each level. Calculate the average scores from three images presented by each experiment with different combinations of display parameters, and save it as the final data.

10.2.3.6 Analysis of the Result

Record the evaluation scores given by viewers for each image and complete the calculation process as shown in Table 10.4.

Table 10.4 The average of evaluated scores in every group

Group	1	2	3	4	5	6	7	8
Avg	2.16	2.25	2.25	2.16	2.08	2.08	2.08	2

According to the data, colors were slightly yellowish on occasion of D50 color temperature, and view feeling of color patch was rather partial dim and had a big difference with the print. On the D65 color temperature, observers were allowed to adapt to the orient with the given color temperature. It can reduce the effect of the color temperature in the comparison. Overall, the soft proofing with a D65 color temperature is more likely to be accepted by observers.

10.3 Summaries

The comparison of ΔE, psychophysical experiments, and analysis of stability and the tendency about each variation component were carried out. The result of experiments showed that the monitor brightness has less effect on simulating color and has good stability. Overall, the hue of monitor trends to green and yellow. Results indicated that Eizo display has the parameters combination of D65 color temperature, 100 on brightness, and 1.8 on gamma value and can make the appearance of soft proofing more easily acceptable.

References

1. Tian, Q. (2004). The influence of gamma value on display. *Printing Engineering*, 43–44
2. Marin, J. (2011). Calibration and profiling for soft proofing. *Printing Industries of America*
3. Hong, L., & Jiang, X.-z. (2012). *Research of liquid crystal display color management standardization: Printing quality and standardization* (pp. 29–34, p. 6).
4. Fleming III, P. D., Sharma, A. *Color management with ICC profiles: Can't live without it so learn to live with it* (p. 19).
5. Liang, H. (2013). *Quality evaluation of LCD monitor characteristic profile: Printing quality and standardization* (pp. 38–43, p. 6).
6. Zhao, B., Zheng, Y. –l. (2012). *Evaluation on the performance of color-difference formula under various viewing conditions: China printing and packaging study* (Vol. 04 24–28, p. 5).
7. Fleming III, P. D., Chovancova, V., Starr, B., Sharma, *A. CRT and LCD Monitors for Soft Proofing* (p. 28).