A New Evaluation Method of Reflective LCDs

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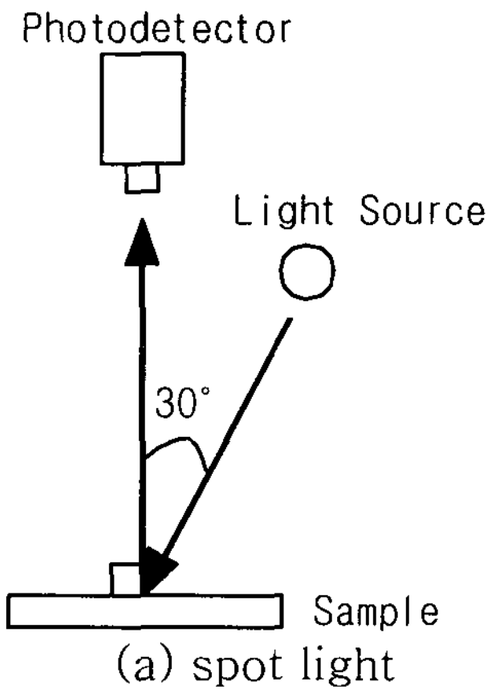
Abstract

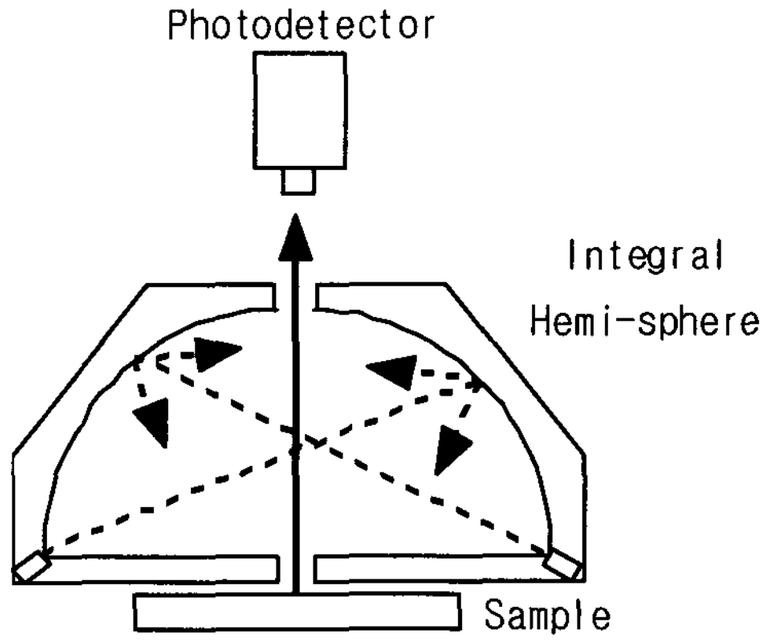
Quality of the reflective LCD as a display is strongly influenced by the environment where the display is evaluated. Up to now, several methods for the evaluation of the reflective LCDs have been proposed. We have developed a new method in which the optical characteristics of the reflective LCDs from the spot light and the diffuse light can be obtained at the same time. The results obtained in our experiments by using the new method showed a good agreement with those evaluated at office and outdoor environments.

1. Introduction

Reflective LCDs, featuring low power consumption and light weight, are capable of various applications, such as PDA, cellular phone, and game devices. Although any backlight equipment is not necessary in reflective LCDs, the optical properties tend to vary significantly by the external light sources. Fig.1 illustrates the conventional method for the measurement of the optical properties of reflective LCDs utilizing the spot light or the diffused light as a light source[1,2]. Recently, several new methods have been suggested by others [3,4,5].



(a) spot light



(b) diffused light

Fig1. Conventional measurement system of reflective LCDs.

Here we present a new method for the measurement of the optical properties of reflective LCDs using the spot light and the diffused light simultaneously.

2. The optical measurement under real illumination conditions

(1) Engineering of human at viewing reflective LCDs

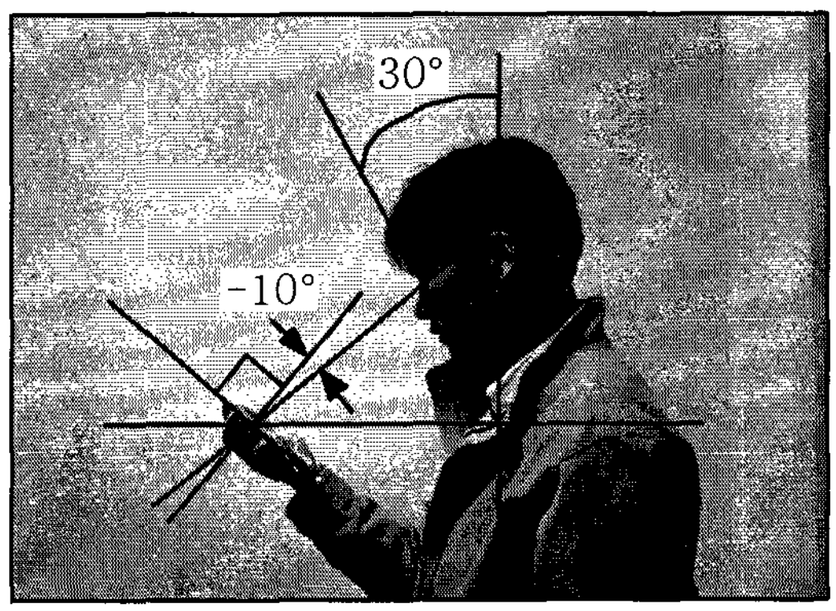
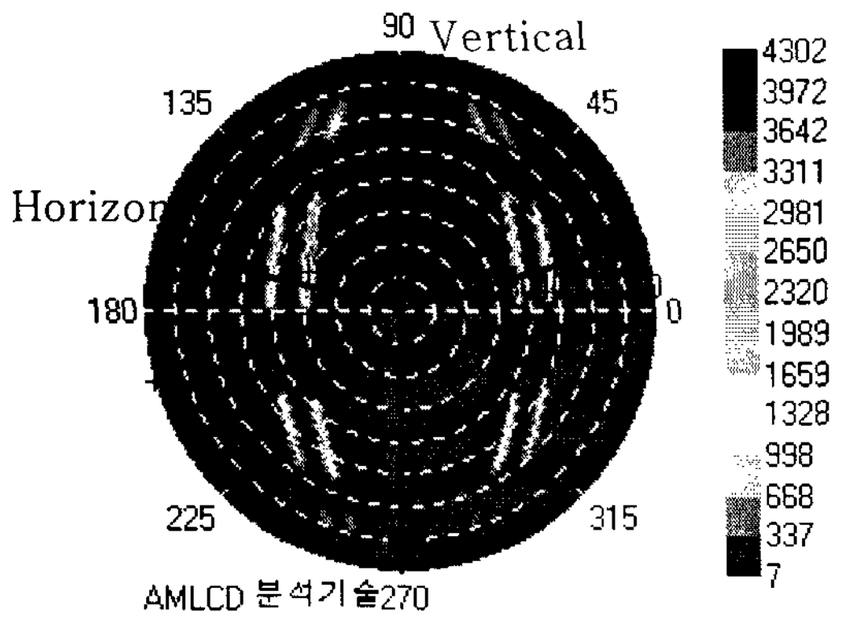


Figure 2. A model using reflective LCDs.

Through research on user's behavior at viewing the reflective LCDs, we have concluded that a regular user has a tendency to tilt LCD devices down to 10° from the vertical direction and look at them with downcast head about 30 °(Fig. 2).

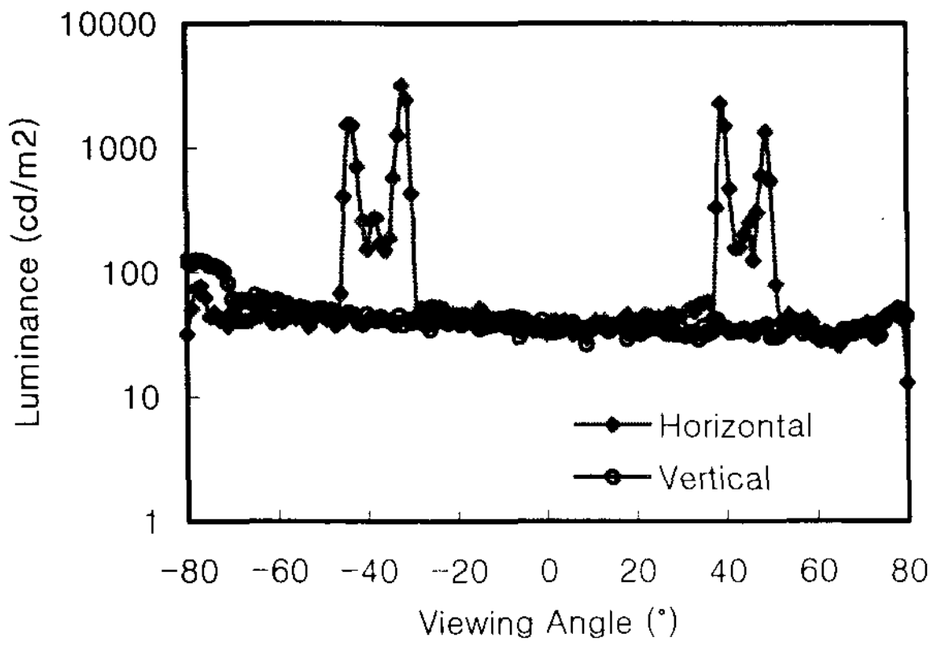
(2) Light distribution of office

Generally, the lighting distribution in the common office environment displays both the direct light and the diffused light characters. The direct light from the fluorescent lighting is similar to the spot light, and any light scattered from the wall and other office supplies are regarded as the diffused light(Fig. 3).



(a) conoscopic view

(in a polar coordinate : max. inclination= 80°)



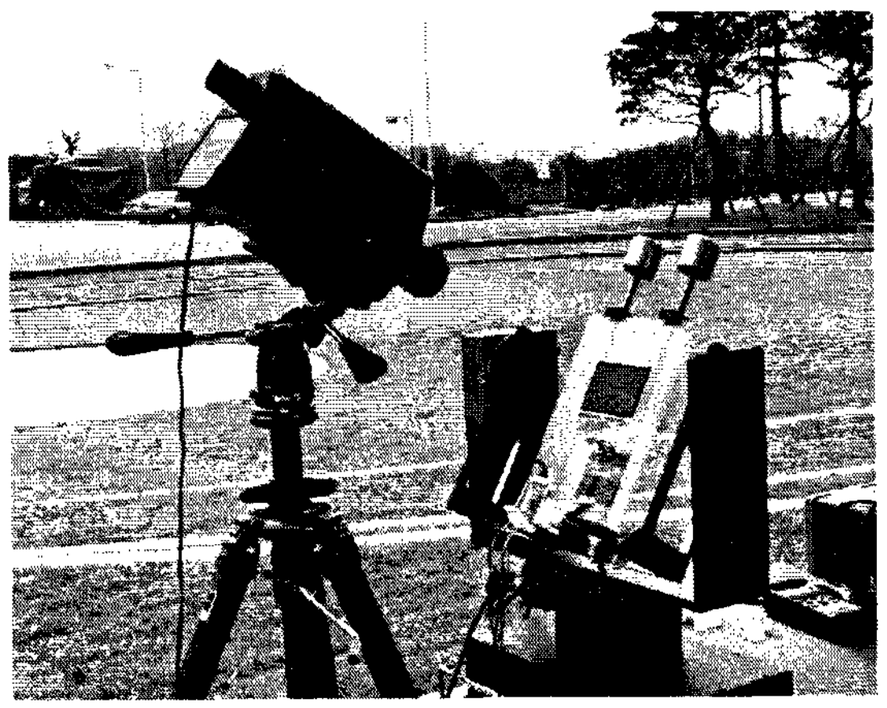
(b) cross-section

Figure 3. Directional luminance distribution in an office of ceiling. (Eldim EZ-Contrast)

(3) Measurements of the optical properties of reflective LCDs under real lighting environments

Under the external lighting environments, we have measured the optical properties of reflective LCDs with Topcon BM-5A photometer shown in Fig. 4 with a downcast photometer about 30°. The aperture is 2°, and reflectance and color coordinate were measured based on the white standard ($BaSO_4$, reflectance factor : 99.8%) and the standard light D65. The measurements in office environment have been made at the midpoint of two fluorescent lights on the ceiling. As for the outdoor environment, we have measured in cloudy weather. The results are shown in Table 1.

(a) office



(b) outdoor

Figure 4. The arrangement of the photometer and a reflective LCD under real lighting environments.

Split	Reflect-ance (%)	C/R	White Color	Gamut (%)
Office [400lx]	14.5	8.2	0.315, 0.340	6.3
Outdoor [15000lx]	16.9	8.9	0.310, 0.340	6.0

Table 1. The optical properties of a reflective LCD under the real lighting environments.

3. New evaluation method (Hybrid method) of reflective LCDs

As mentioned above, the environments where reflective LCDs are being handled pertain to the spot light and the diffused light. Therefore, these light sources were applied to in our new method used these light sources. Also according to our research on user's tendency, the measurements were made at 10° down from the vertical direction. Reflectance and color coordinate were measured based on the white standard ($BaSO_4$, reflectance factor : 99.8%) and the standard light D65. The equipment, Otsuka LCD-7000 was used. The luminance ratio of the spot light and the diffused light were chosen to be 1 to 3. Table 2 is the resulted from the new method.

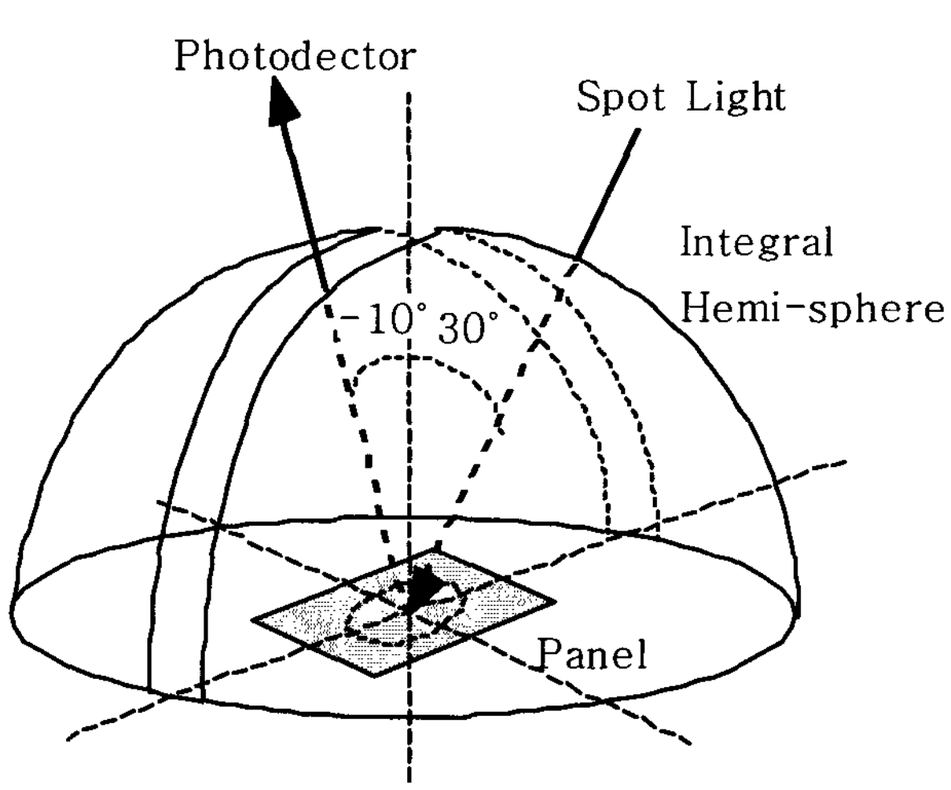


Figure 5. New measurement method of reflective LCDs(Hybrid method).

Split	Reflect-ance (%)	C/R	White Color	Gamut (%)
Spot	27.2	24.4	0.314, 0.346	8.8
Diffuse	13.2	7.2	0.306, 0.331	4.5
Hybrid	15.1	10.4	0.312, 0.341	6.2

Table 2. The optical characteristic of reflective LCDs using new measurement methods.

4. Discussion

As depicted in Fig. 3, it is clear that in the office environment, an area near to the fluorescent lighting gives the characteristic of the spot light while other area affords that of the diffused light. Considering such a spatial distribution of the light sources, the light sources for the precise measurement of reflective LCDs should be a hybrid of the spot light and the diffused light. Although hybrid method is not a perfect method in measuring the optical properties of reflective LCDs, it must be an effective method to get good results close to the real values in the actual environments. Compared with the results from the singular light sources, the spot light and the diffused light, it was found that the optical properties of the reflective LCDs under the real lighting environments is close to that obtained in the diffused light. As a consequence, the luminance ratio of the spot light and the diffused light were adjusted to be 1 to 3 in the new hybrid method and the more precise results was yielded. By studying user's behavior at viewing reflective LCDs, it was found that the appropriate angle of measurement is 10° down from the vertical lower direction.

Comparing results from Table 1 and Table 2, the results from our hybrid method are very close to the measurements made in the actual external lighting environments.

5. Conclusion

We developed a new hybrid method in which the optical properties of the reflective LCDs from the spot light and the diffused light can be obtained at the same time. Since the new hybrid method was modified from the conventional method, the actual optical properties of the reflective LCDs could be obtained with any instrument with the spot light and the diffused light.

6. References

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