Image Quality Comparison Between LCD and PDP Based on Subjective and Objective Evaluation

Keita Hirai [*], *Shinichi Sano* [**], *Jie Bai* [*], *Masayuki Ukishima* [*],
Toshiya Nakaguchi [**], *Norimichi Tsumura* [**], *Yoichi Miyake* [**,***]

[*]*Graduate School of Science and Technology, Chiba University*
[**]*Department of Information and Image Science, Chiba University*
[***]*Research Center for Frontier Medical Engineering, Chiba University*
Chiba, Chiba/Japan

Abstract

In this paper, we evaluated the image quality of movies displayed on LCD (Liquid Crystal Display) and PDP (Plasma Display Panel) subjectively and objectively. Image quality criteria such as the gonio photometric characteristics, luminance, chromaticity, gazing area and motion blurs of LCD and PDP are measured and analyzed.

The relationship between observer rating values based on paired comparison method and those obtained physical criteria for 19 kinds of movies is described and discussed.

Introduction

Recently, flat panel displays become significantly larger and thinner according to the development of the technology. Particularly liquid crystal displays (LCDs) and plasma display panels (PDPs) have been widely used instead of traditional cathode-ray tube (CRT). As the displays have been popular, it is the important tasks to compare their characteristics and performances such as image quality, electric power consumption, the life spans, functionalities, etc. Particularly, the comparison of the image quality is the most important issue for the displays.

The image quality between LCDs and PDPs can be compared mostly by the gonio photometric characteristics, sharpness, motion blurs, color reproduction, tone reproduction and so on. PDPs reproduce dark scenes very well, because each pixel of PDPs is luminiferous by itself. In addition, the features in motion pictures such as response time and a motion blur are better than that of LCDs. Because of controlling the brightness based on masking the backlight by using liquid crystals, LCDs have good appearance in bright scenes. They also have the gonio characteristics that are direction-dependent luminance characteristics. However these characteristics are sometimes discussed based on the developers' subjective opinions without the physical criteria.

In this research, we evaluated the image quality of a LCD and PDP subjectively and objectively. For the purpose, we noticed the gonio photometric characteristics, the motion blur and the color reproduction of various movies obviously including dark and bright scenes. Particularly, for evaluating the motion blur and the color reproduction, the observer rating values and those physical criteria were obtained. We also discuss the relationship between them.

Gonio Photometric Characteristics

We measured the gonio photometric characteristics of the LCD (AQUOS LC-45GD1, Sharp) and the PDP (VIERA TH-42PX300, Panasonic) by the following conditions with a spectral radiance photometer as shown in Fig. 1.

Input image level: 0-100% (17 steps)
Input image size: full-screen
Distance from the displays to the photometer: 150 cm
Angle (θ): 0, 15, 30, 45, 60, 75 degrees
Measured point: center of the displays
Environment of room: dark room

Figure 2 shows the gonio photometric characteristics of the LCD and PDP when input image level is 100%. The luminance of LCD decreases precipitously over 30 degrees. In contrast, the PDP keeps the almost same luminance from 0 to 45 degrees. The results clearly show the gonio photometric characteristic of the PDP is much better than that of LCD.

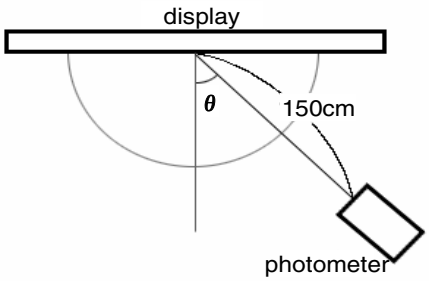


Fig.1 The experimental geometry to measure the gonio photometric characteristics

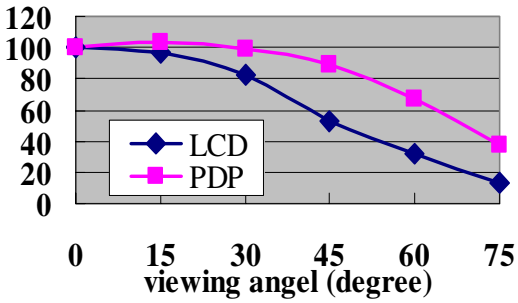


Fig.2 The gonio photometric characteristics of the LCD and PDP. In the figure, the values of the vertical axis are normalized as the luminance at 0 degree is 100. The luminance of the PDP at 0 degree is 236cd/m^2 and that of the LCD is 519cd/m^2.

Motion Blur Evaluation

Moving picture response time (MPRT) has been used to quantify the motion blurs on displays[1][2]. In this research, we measured and compared the physical motion criteria of the LCD and PDP based on the MPRT method.

Moving Picture Response Time

In the MPRT method, it is required to obtain the blurred edge images that move on the displays horizontally to calculate the MPRT. The unit is milli-second and the smaller the criterion, the less the motion blur.

In the measurement, 42 edge test patterns (7 kinds of gray scale images are prepared for each left and right side images) are used. The images before the edge passes (right side) are called 'initial gray' and them after the edge passes (left side) are called 'final gray.' The gray scale images are defined as following Eqs.(1). Where Y6 is the maximum luminance of the display and Y0 is minimum one.

$$L0 = 903.3 \cdot Y0/Y6 \quad for \quad Y0/Y6 < 0.008856$$
$$Yn = Y6 \cdot \left(\frac{(L0 + (100 - L0) \cdot n/6) + 16}{116} \right) \qquad (1)$$
$$n \in \{0,1,2,3,4,5,6\}$$

MPRT Measurement

The measured results based on the MPRT method are shown in Fig. 3. A part of the LCD's results is excepted because the patterns' exposures were too short to calculate the MPRT. In the patterns of high luminance, it is almost no difference between the LCD and PDP. On the other hand, the PDP performs much better in them of low luminance.

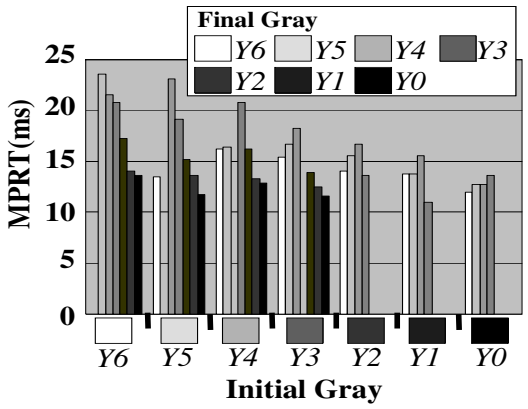
Subjective Evaluation Experiment for Movies with Noticeable Motion

We also obtained the observer rating values on the motion of the pictures based on the paired comparison method. The 11 observers evaluated 3 kinds of the movies that especially had the feature with noticeable motion. The observers were asked to select the LCD or PDP which they felt sharply. Figure 4 shows the experimental room for the evaluation. The viewing distance was 3.1m and the room radiance was 150lux.

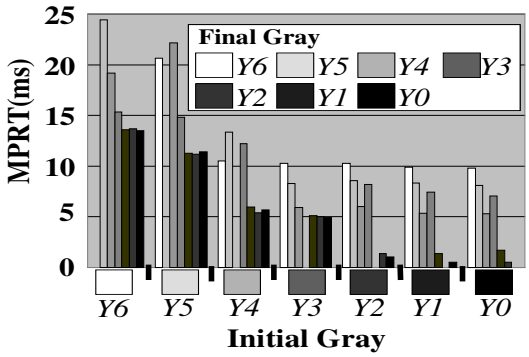
The observers evaluated the displays twice under the two different LCD's backlight conditions because it was high possibility for the observers to evaluate the display with higher luminance. The two conditions are as follows.

1. primary setting of a factory (LCD-1).
2. the setting based on the adjusted LCD's backlight which luminance is correspond to the PDP's when they display 18% gray image(LCD-2).

Table 1 shows the result of the observer rating values. In the table, the values show the ratio that the PDP is superior to the LCD. In both the LCD's backlight conditions, it is showed that the PDP is superior to the LCD. It is correspond to the results of MPRT.



(a)



(b)

Fig. 3 The measured MPRT (a)LCD (b)PDP

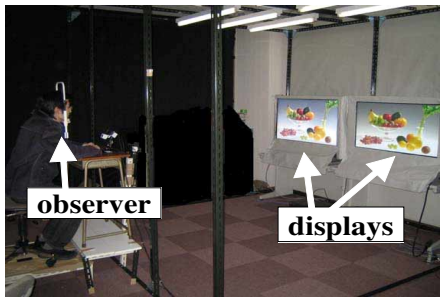


Fig. 4 The room for the subjective evaluation experiments

Table 1 The ratio that PDP is superior to LCD when the observers watched the movies with noticeable motion

Kind of Movie	Ratio of PDP to LCD-1	Ratio of PDP to LCD-2
movie 1	54.5 %	36.4 %
movie 2	90.9 %	100 %
movie 3	72.7 %	54.5 %
average	72.7 %	62.6 %
total average	68.2 %	

Evaluation of Tone and Color Reproduction

In this section, we describe the observer rating values to evaluate the tone and color reproduction of various movies. Moreover, the relationship between the observer rating values and the measured physical criteria of the representative frames is discussed.

Subjective Evaluation Experiment

The subjective evaluation experiment based on the paired comparison method was done by 43 observers. The observers evaluated the 16 movies from 15 to 20 seconds that were classified into 6 categories based on the features. For each movie, they were asked to select the LCD or PDP which they felt better appearance in whole. (We also obtained their gazing areas. See [3].) After the experiments, the observers described some comments freely and selected the image quality keywords (table 2) optionally to obtain the impression of the displays. The experimental environments were the same as the subjective experiment for noticeable motion.

Table 3 shows the 6 categories of the movies and the results and table 4 shows the results categorized based on the observers' age, the their knowledge of image quality and the conditions of the LCD's backlight. In both the tables, the values show the ratio that the PDP is superior to the LCD. From the result that 'dynamic range' ratio was 96% as shown in table 3, it is clear that dark scenes displayed on the PDP are much better than the LCD. In contrast, the LCD has better results in the categories of 'memory color (nature)' and 'colorfulness'. Figure 5 shows the representative frames of 'dynamic range' and 'colorfulness.'

By analyzing the obtained image quality keywords, we could also see the observers have some strong impressions that the PDP was 'soft,' 'warm,' 'natural' and 'prefer,' and the LCD was 'brilliance,' 'stereoscopic' and 'heavy.' We also obtained many comments that the PDP was 'good appearance in dark scenes,' 'soft' and 'natural' and the LCD was 'brilliance' and 'unnatural.' These comments tend to correspond with the observer rating values.

Measuring Physical Criteria

In the objective evaluation experiments, the luminance and chromaticity of the representative frames from each movie were measured. Figure 6 and 7 show the luminance and *xy* chromaticity histograms of the images shown in Fig.5. The *xy* histograms of LCD-2 is omitted because the histogram of LCD-1 is similar to LCD-2.

Comparison of Image Quality between LCD and PDP

In dark scenes, the luminance histograms of the PDP disperse more widely than the LCD. It means that the PDP can represent fine luminance steps in the images including low luminance areas mainly. Then it is considered that the luminance histograms' distribution causes the observer rating values and the comments that the dark scenes of the PDP are good appearance. On the other hand, we consider the LCD can represent better appearance in the movies with high dynamic range as shown in Fg.7, because the better observer rating values for the LCD were obtained for the such movies.

Table 2 The image quality keywords

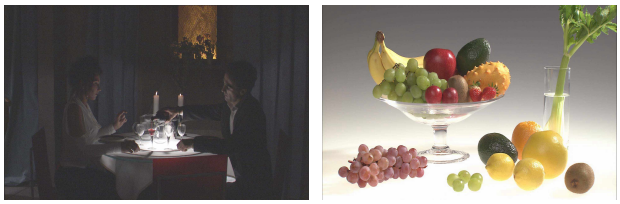
Soft－Hard	Reality－Virtual
Warm－Cool	Prefer－Dislike
Colorful－Sober	Impression－Poor
Light－Dark	Heavy－Light
Fine－Coarse	Natural－Artificial
Brilliance－Cloudy	Smooth－Rough
Stereoscopic－Planer	

Table 3 The ratio that PDP is superior to LCD

Category	Ratio of PDP
memory color (skin) :3 movies	55.8 %
memory color (nature) :2 movies	36.6 %
colorfulness :3 movies	26.0 %
dynamic range (mainly dark scenes) :4 movies	94.8 %
texture (ice, metal, etc.) :3 movies	45.3 %
sharpness :1 movie	65.8 %
total average	56.2 %

Table 4 The ratio that PDP is superior to LCD (age, common observers and the observers with the knowledge of image quality, different conditions of LCD backlight)

Category	Ratio of PDP
20~29 years old (28 observers)	54.6 %
30~39 years old (3 observers)	57.3 %
40~49 years old (5 observers)	50.0 %
over 50 years old (7 observers)	66.5 %
common observers (30 observers)	55.4 %
observers with the knowledge of image quality (13 observers)	57.9 %
comparison with LCD-1	53.3 %
comparison with LCD-2	59.0 %



(a) *(b)*

Fig. 5 The representative frames of the movies (a)Dynamic Range (b)Colorfulness

Though we can see that the *xy* histograms of the LCD are different from the PDP's, some observers described 'I felt the LCD's color was unnatural, but preferred it' as their comments. As the shown comment, it is difficult to discuss the relationship between the measured chromaticity and the observer rating values.

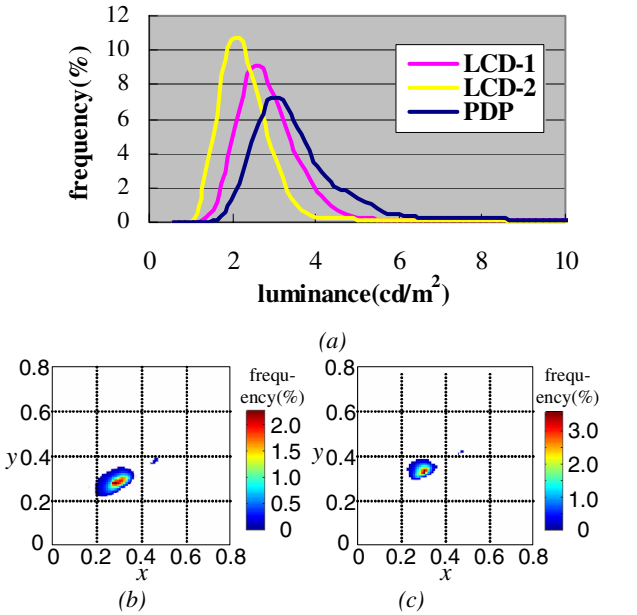


Fig.6 (a)~(c): The luminance histogram, xy chromaticity histogram (LCD-1) and xy chromaticity histogram (PDP) of Fig.5(a)

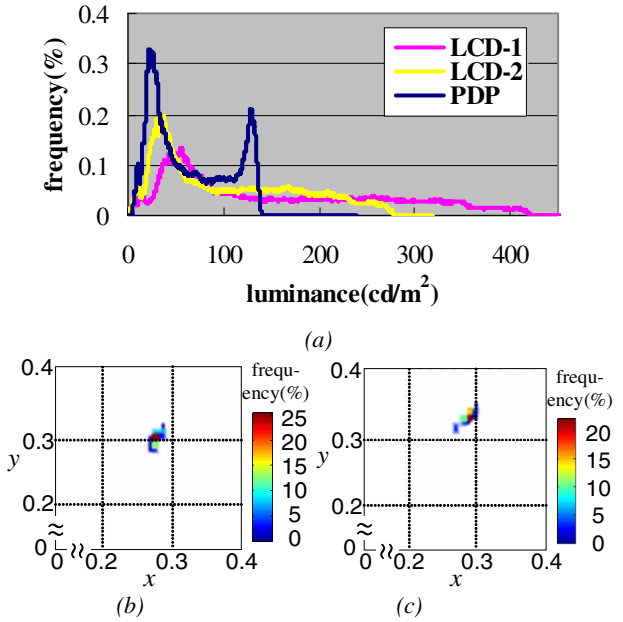


Fig.7 (a)~(c): The luminance histogram, xy chromaticity histogram (LCD-1) and xy chromaticity histogram (PDP) of Fig. 5(b).

Conclusions

We compared the image quality between the LCD and PDP. The image quality criteria such as gonio photometric characteristics, MPRT, luminance and chromaticity of the representative frames from the movies were measured. Moreover, the observer rating values for the motion blurs, the tone reproduction and the color reproduction were measured and analyzed. The results of gonio photometric characteristics and MPRT showed that the PDP has good performance. It was also showed that the observer rating values for the movies corresponded to the conventional empirical opinion that the PDP can represent good appearance in dark scenes and the LCD in bright scenes. We also described one of the factors in such results come from the distributions of the luminance histograms.

In this paper, we noticed the gonio photometric characteristics, the motion blur and the color reproduction of the displays, and in the future, we will obtain more observer rating values and physical criteria and analyze the relationship.

Acknowledgements

We would like to thank Dr. T. Kurosawa, S. Minami, H. Yoshida, K. Adachi and N. Khang, Matsushita Electric Industrial Co., Ltd., for their useful discussions and supports.

References

[1]Jun Someya, "Correlation between Perceived Motion Blur and MPRT Measurement," SID 05 DIJEST 1018-1021, 2005.

[2]Youishi Igarashi, "Summary of Moving Picture Response Time (MPRT) and Futures," SID 04 DIJEST 1262-1265, 2004.

[3]Jie Bai, Keita Hirai, Masayuki Ukishima, Shinichi Sano, Toshiya Nakaguchi, Norimichi Tsumura and Yoichi Miyake, "Considering Temporal Change of Eye Movement for Image Quality Evaluation," ICIS'06 (to be published).

Author Biography

Keita Hirai received B.E. degree in the Department of Information and Image Science from Chiba University in 2005. He is currently a master course student in Chiba university. He is interested in image quality research, especially appearance of video images and evaluation of flat panel displays.