New Evaluation Index of Ambient Image Quality Considering Reflectance Characteristic of Display

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ABSTRACT

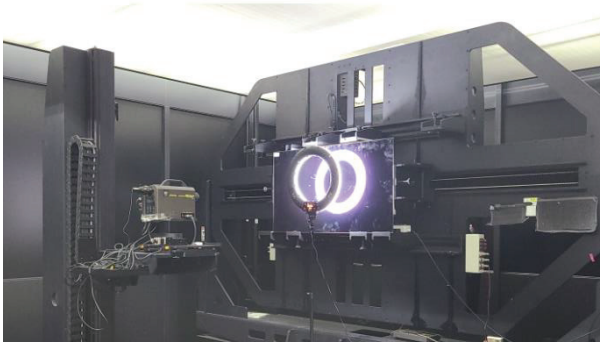
The important factors that determine the image quality of a display include black tone, color gamut, and color accuracy. A new evaluation method is introduced that can measure the image quality of a display under a TV viewing environment with external lighting, and provide evaluation results for several displays.

1 Introduction

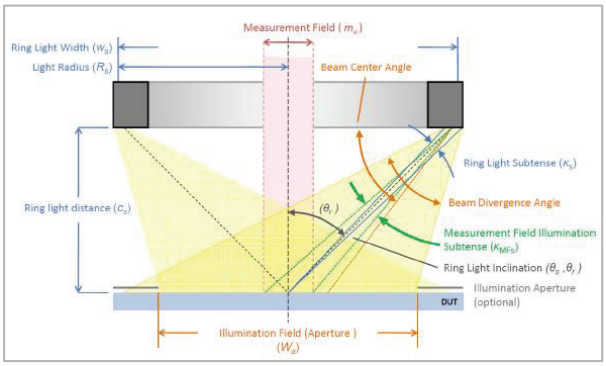
With the development of display, the technologies that determine the image quality have also developed a lot, and the image quality of the display that is being developed recently shows very good characteristics in a dark environment. However, we don't have much time to watch the display in a dark environment. The environment in which we view the display is generally a living room, and we watch the display in the presence of lighting. Many people have experienced that when watching TV in a bright living room during the daytime, the screen is less visible than when watching in a dark environment. This phenomenon occurs because light incident on the display from the external environment is reflected and offset with the light transmitted from the display. Due to this problem, in the recent display market, various studies have been made on the reflective characteristics of the display. The author intends to review a method that can quantitatively evaluate the reflection characteristics under conditions similar to the actual viewing environment among various methods that can examine the reflection characteristics of the display. And with the recently released TV products, we want to check the results of evaluation of reflection characteristics related to image quality.

2 Method

There are many different environments in the actual TV viewing space where external lighting exists. Since it is physically impossible to evaluate all such environments, it is necessary to set up an experimental condition in which external light could be stably incident on the display. We conducted an experiment based on the Ring Light Reflection evaluation method specified in IDMS (International Display Measurement Standard) 11.5. Measuring equipment was installed as shown in [Fig. 1].



[Fig. 1. Experimental set-up for ring light reflection evaluation]



[Fig. 2. Details of ring-light configuration, side view, IDMS 11.5]

3 Experiment

In this experiment, we compared and analyzed image quality according to illumination conditions using recently released TV products. The TV Displays will be evaluated in three types: WOLED, QD-OLED, and LCD, and black luminance characteristics, color gamut, and color shift according to illuminance conditions will be evaluated. The experimental procedure is as follows.

1) The ring light is placed horizontally with the test sample.
2) In order to minimize the specular reflection

component, it is positioned so that the light emitted in the 45° direction from the illumination can be incident in the opposite 45° direction.

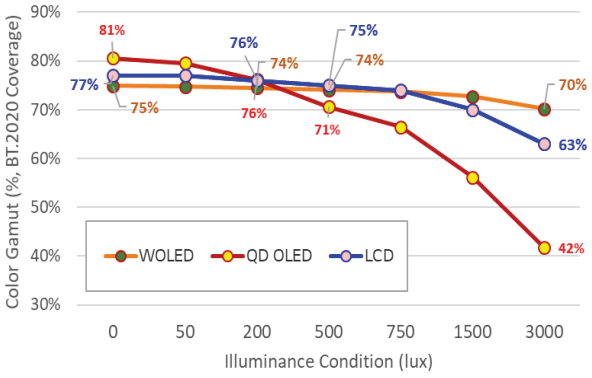
3) The detector is positioned at the front (On-Axis) of the test sample and measured. (working distance: 1,000mm)
4) Measure Luminance / Chromaticity of WRGB and Black according to the illuminance condition. (Illumination condition: 50 / 200 / 500 / 1,500 / 3,000 lux)
5) All measurements are taken 5 times and the average value is applied.

4 Result

It has been completed the measurement of Luminance / Chromaticity under the illuminance conditions of three types of TVs through experiments. In the display, when the diffuse reflection was high, the image quality under the illumination condition was changed. Three evaluation items are proposed that can quantitatively evaluate the image quality change according to the difference in reflectance. The evaluation items are proposed, such as Ambient Black Luminance (ABL), Ambient Color Shift (ASC), and Ambient Color Gamut Decrease Ratio (ACGDR).

4.1 Ambient Black Luminance (ABL)

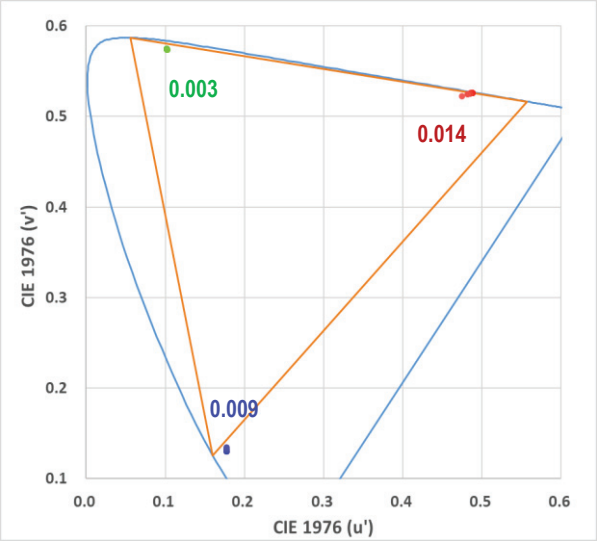
Black Luminance is the factor that has the greatest influence on the contrast ratio when viewing a display. However, when external illumination is present, the black luminance of the display shows a different phenomenon from that in the dark room. The black luminance in the darkroom shows very low luminance. However, as the external illuminance gradually increases, the black luminance gradually increases according to the reflective characteristics of the display.



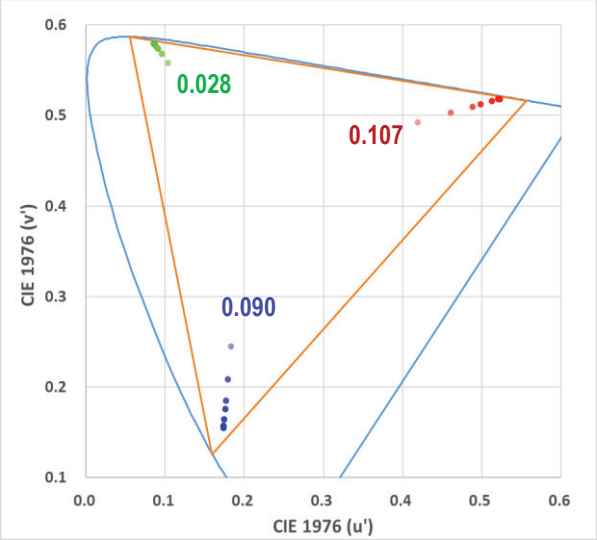
[Fig. 3] Detection luminance compared with the black level of three displays in external illumination.

4.2 Ambient Color Shift (ACS)

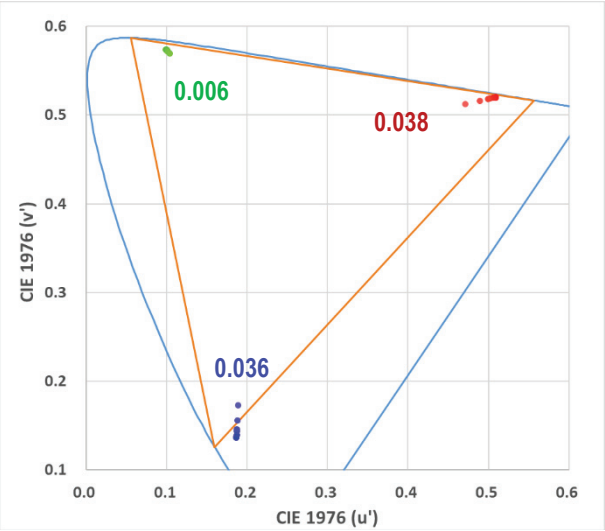
Similar to the black luminance change according to the external illuminance change, it was confirmed that the chromaticity characteristic also changed. When the external illuminance increases, the color coordinates of RGB primary color gradually deviate from the color coordinates in the dark room. The graphs from Fig.4 to Fig.6 are the results of expressing the change in RGB color coordinates in the CIE1976 color space when the external illuminance changes from 0 lux to 3,000 lux. The number in the graph is the Δu'v' value, and in the ISO 13406-2 standard, the thresholds Δu'v' value for human perception of color change is 0.02 or less.



[Fig. 4] WOLED Result color coordinates difference (delta u'v') RGB in external illumination.



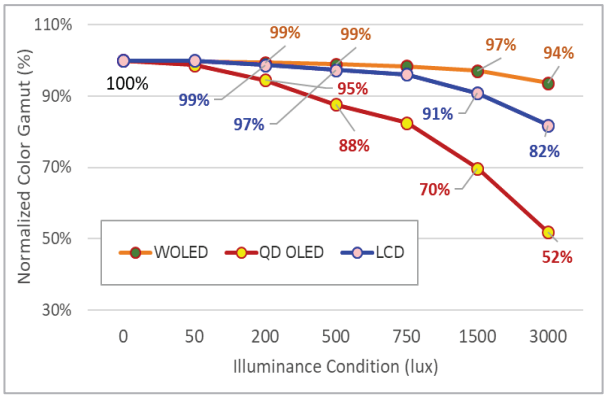
[Fig. 5] QD OLED Result color coordinates difference (delta u'v') RGB in external illumination



[Fig. 6] LCD Result color coordinates difference (delta u'v') RGB in external illumination

4.3 Ambient Color Gamut Decrease Ratio (ACGDR)

As seen in ACS, the reduction of the RGB color coordinates in relation to the increase in external illuminance greatly affects the color gamut. For the color gamut used in this experiment, the coverage in the BT.2020 color space was applied, and it was observed that the color gamut decreased as the illuminance increased.



[Fig. 7] Color gamut decrease ratio according to changes in external illuminance

5 Conclusion

Most TV viewers watch the display in an environment exposed to external light. When the display is exposed to external light, it exhibits different luminance and color characteristics. But the specifications of the display products are presented only in dark room condition. In this experiment, we are not trying to find a display product with good visibility in the external environment. However, I were thought that the specifications presented by the displays being made with the latest technology are those in darkroom conditions, and this could lead to consumers making the wrong decision. It was proposed a new evaluation method and index that can evaluate the image quality under the illuminance condition of the display. The three evaluation indicators (ABL, ACS, ACGDR) do not represent all of the display's reflective properties. However, it is thought that a new reflection characteristic evaluation method is necessary because various errors may occur in predicting the reflection characteristics of the display using only the current reflectance value. We will continue to study the image quality of the display according to the external environment becomes more and more important.

References

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