The Study on New Evaluation Index of Color MPRT (Motion Picture Response Time) Considering Human Sensitivity Characteristic

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ABSTRACT

In this study, we introduce a new evaluation index for color motion blur characteristic using Color MPRT (Motion Picture Response Time). We have already introduced the Color MPRT in SID 2019, and this study proposes a new evaluation index for C-MPRT based on the C-MPRT evaluation method.

1. INTRODUCTION

Motion blur is very important factor for a human to see a quality image on a display. There are several ways of evaluating Motion Blur. The most representative method currently used is the motion picture response time (MPRT) proposed by the IDMS standard.

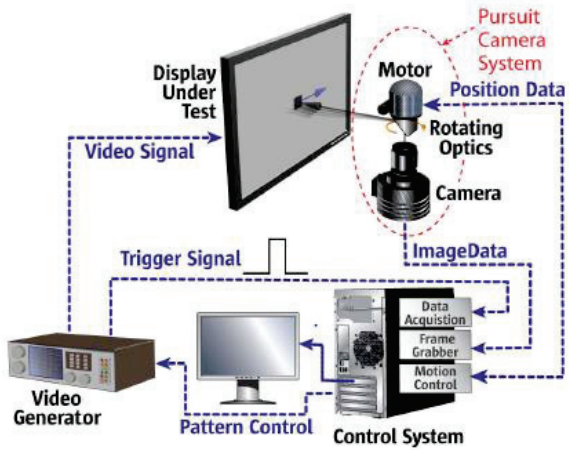
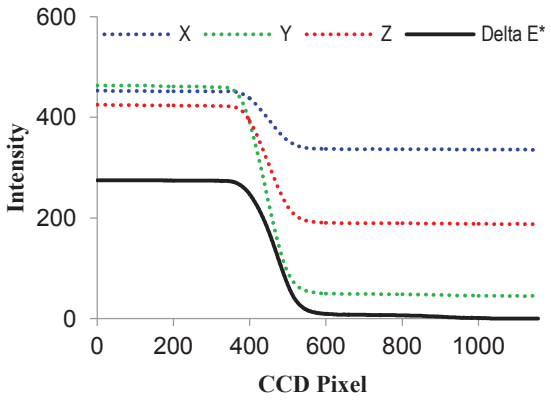
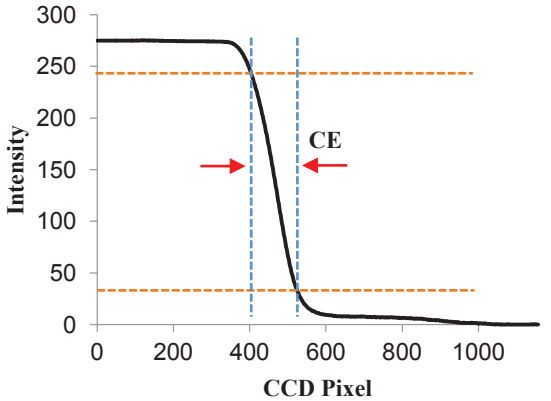


Fig. 1 MPRT measurement System with a pursuit camera (IDMS, 2012, p.243)

However, the current MPRT evaluation method is an evaluation method that considers only the luminance component, and motion blur of the color component cannot be measured. So we developed the Color MPRT Assessment in 2018 and presented it at SID 2019. C-MPRT measurement method that we developed was MPRT-2000 utilizing the equipment used to measure the existing MPRT. The mentioned MPRT measurement system which has the RGB CCD camera can measure the blur of the color information. The measurement of color blur is the same way as brightness blur. The test image which has two areas with each different color scrolls and the red, green and blue CCD capture the blur of each color. The system calculates the XYZ tristimulus values from each color blur because the RGB CCD was calibrated using RGB to XYZ conversion. The tristimulus values X, Y and Z are converted to L*, a* and b* and the delta E* is calculated as shown below the equation 3. The reference color is one which has the smallest amount of luminance from the start or end color. The values of L*ref, a*ref and b*ref are the saturated values of the reference color.



(a) XYZ to L*a*b* conversion and ΔE* calculation



(b)A color edge width of the plot ΔE*

Fig 2. A color CET measurement

$$\Delta E^* = \sqrt{\left(L^*_{ref} - L^*_i\right)^2 + \left(a^*_{ref} - a^*_i\right)^2 + \left(b^*_{ref} - b^*_1\right)^2}$$

$L_{ref}^*, a_{ref}^*, b_{ref}^*$: Saturated start or end color

L_i^*, a_i^*, b_i^* : Measured data

Based on the C-MPRT measurement method, the development of a new C-MPRT evaluation index was examined. The first evaluation index we examined was to select the average of the C-MPRT values measured for each color change as the representative method. However, the index using the average was difficult to represent the overall Color Motion Blur. If the C-MPRT value is similar for each color, the color motion blur can be represented as an average value. Otherwise, a difference occurs in the level of C-MPRT perceived by a person in a specific color. So we examined a new evaluation index that can take into account all the distributions of C-MPRT values that occur due to color changes.

2. EXPERIMENT

We had to choose the appropriate color to examine the color motion blur characteristics of the display. The primary 7 colors are White, Red, Green, Blue, Magenta, Cyan, and Yellow, which are often used for display measurement, and Macbeth 24 colors, which consist of mixed colors, are used to examine a variety of colors. We first measured the C-MPRT level of the display using primary 7 colors based on the C-MPRT measurement method mentioned above. The measurement results are shown in [Table 1].

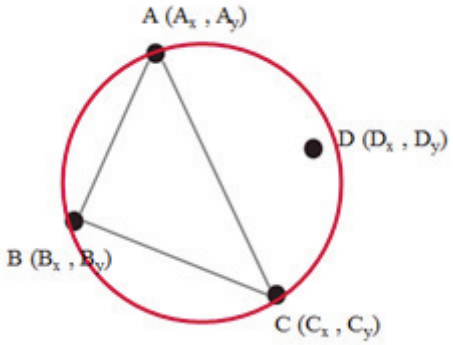
C-MPRT		End Color						
		White	Red	Green	Blue	Cyan	Magenta	Yellow
Start Color	White		24.4	10.1	9.2	10.3	9.3	10.5
	Red	10.3		12.7	10.2	10.7	10.0	12.0
	Green	10.6	14.9		9.1	9.8	8.6	12.9
	Blue	13.3	14.4	11.0		12.1	12.5	11.7
	Cyan	12.1	22.5	10.4	9.3		7.5	10.3
	Magenta	12.5	23.1	10.2	9.7	12.1		10.9
	Yellow	10.2	10.0	12.0	9.4	9.6	9.7	

Rising Area

Falling Area

Table 1. Measurement result of primary 7 color

In order to consider the C-MPRT value for the entire color based on the measurement result using the primary 7 color, we tried to implement the measurement result in the form of 3D plot. To implement the 3D plot with the result data we used DT (Delaunay Triangulation) [See Fig.3]. In short, Delaunay Triangulation is the division that connects the points on the plane into triangles and divides the space so that the minimum value of the inner angle of these triangles is maximum. It is a geometric calculation technique mainly used to calculate the volume of density function. It is a method of constructing triangles of all points so that no other points are included in the circumscribed circle of vertices.



$$\begin{vmatrix} A_x & A_y & A_x^2+A_y^2 & 1 \\ B_x & B_y & B_x^2+B_y^2 & 1 \\ C_x & C_y & C_x^2+C_y^2 & 1 \\ D_x & D_y & D_x^2+D_y^2 & 1 \end{vmatrix} = \begin{vmatrix} A_x-D_x & A_y-D_y & (A_x^2-D_x^2)+(A_y^2-D_y^2) \\ B_x-D_x & B_y-D_y & (B_x^2-D_x^2)+(B_y^2-D_y^2) \\ C_x-D_x & C_y-D_y & (C_x^2-D_x^2)+(C_y^2-D_y^2) \end{vmatrix}$$

$$= \begin{vmatrix} A_x-D_x & A_y-D_y & (A_x-D_x)^2+(A_y-D_y)^2 \\ B_x-D_x & B_y-D_y & (B_x-D_x)^2+(B_y-D_y)^2 \\ C_x-D_x & C_y-D_y & (C_x-D_x)^2+(C_y-D_y)^2 \end{vmatrix} > 0$$

Fig 3. Algorithm of the Delaunay Triangulation

2.1 Primary 7 color

Based on the measurement results in Table 1, 3D Plot implementation results show that we can easily distinguish the difference in C-MPRT values by color. [See Fig 4.]

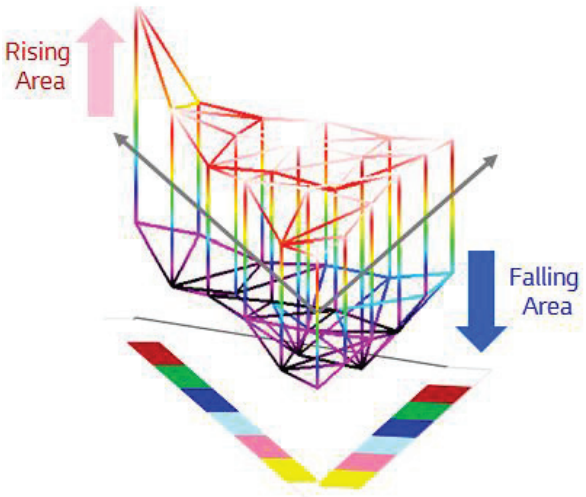


Fig 4. C-MPRT 3D Plot using primary 7 colors

The volume index (VI) and surface area index (SAI) could be calculated by mathematically calculating the volume and surface area of the 3D plot. The volume index shows the overall C-MPRT level of the display, and the surface area index is the result of considering the overall C-MPRT level and the distribution of the measurement results.

2.2 Macbeth 24 color

The result of implementing 3D plot after measuring C-MPRT using Macbeth 24 color with the same display is shown in [Fig. 5.] Since the Macbeth 24 color is composed of mixed colors that can be used more in the actual image than the primary 7 color, it is more suitable for the actual image environment, and more color MPRT characteristics can be considered. Therefore, we want to use the measured value for Macbeth 24 color from the next experiment.

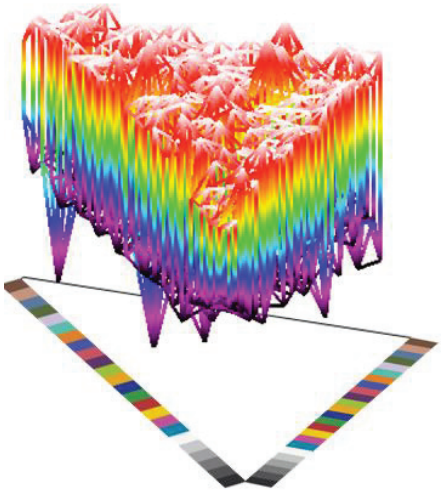


Fig 5. C-MPRT 3D Plot using primary 7 colors

3. Result

We conducted the C-MPRT evaluation of display products using the newly developed C-MPRT evaluation method and index. The products we reviewed are OLED TV and Gaming monitor.

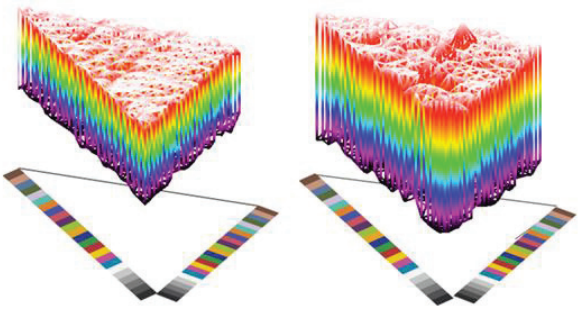


Fig 6. C-MPRT 3D Plot OLED TV & Gaming Monitor

Product	VI	SAI
OLED TV	4,230	5,753
Gaming Monitor	12,714	17,112

Table 2. C-MPRT Result about New Index

In this experiment, we were able to compare the C-MPRT levels of OLED TV and Gaming monitor using the Volume Index and Surface Area Index. In addition, C-MPRT 3D Plot is easily expressed to compare the color motion blur characteristics of the actual display. In particular, in the case of the Gaming Monitor used in this experiment, it can be seen that C-MPRT characteristics are about three times higher than OLED TV. In this result, we should focus on the 3D Plot that the gaming monitor shows a large dispersion due to the different C-MPRT characteristics according to the color, and it is easy to see which color is weak..

4. Discussion

In this Paper, The products used for C-MPRT measurement were OLED TV and Gaming monitor. Recently, Gaming Monitor is applying high speed driving technology to minimize Motion Blur. However, the actual motion blur characteristics are only evaluated using luminance components. Nevertheless, it is difficult to express the motion blue characteristics of the display accurately by the current evaluation method because the image that is applied with a large number of colors is rapidly displayed on the game screen. Therefore, we think that the motion blue characteristics of the display should be evaluated by C-MPRT evaluation method and new index including color.

3. Reference

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