Physically-Based Crosstalk Model in Stereoscopic 3D LCDs

Dong-Gun Lee, Jong-Man Kim and Seung-Woo Lee
Dept. of Information Display and Advanced Display Research Center, Kyung Hee University, Seoul, Korea
Tel.:82-2-961-0957, E-mail: seungwoolee@khu.ac.kr

3D crosstalk is a critical factor determining the image quality of stereoscopic 3D displays. In order to improve it, various crosstalk characteriszation models are proposed. Conventionally, the 3D crosstalk can be expressed as $Y_L^{'} = Y_L + \alpha Y_R$, $Y_R^{'} = Y_R + \alpha Y_L$. Here, Y_L and Y_R represent the luminance for the left and right images, respectively. Y_L' and Y_R' are the actual luminance for left and right eye, respectively. αY_R and αY_L represent the crosstalkfrom right and left images. LCDs have a light leakage problem at a black state [2]. For example, luminance from red channel (YR) can be expressed as $YR = YR^i + \Delta YR + \Delta YG + \Delta YB$ [2]. Here, ΔYR, ΔYG, and ΔYB represent the light leakage from red, green, and blue sub-pixels, respectively. YR^i represents the incremental luminance from red subpixels. We propose a new crosstalk characterization model considering the light leakage problem and show experimental results compared with the conventional method.

We analyzed the crosstalk in steroscopic 3D displays as the following three steps : First, we analyzed the luminance through the 3D glasses when the crosstalk does not exist. Figure 1(a) shows the conceptual image when the left and right images are red and black, respectively. As shown in Fig. 1(a), luminance for the left eye (YR_L') can be expressed as $YR_L^{'} = YR_L^i + \Delta YR_L + \Delta YG_L + \Delta YB_L + \alpha(\Delta YR_R + \Delta YG_R + \Delta YB_R)$. Here, the parameters with subscript L or R represent the luminance information from left or right image in the panel. Secondly, we analyzed the luminance through the glasses when the crosstalk from the counterpart image exists. Figure 1(b) shows the conceptual image when the left and right images are red and green, respectively. In this case, the luminance information for the left eye may be distorted by the counterpart green pixels. As shown in Fig. 1(b), thus, luminance for the left eye can be expressed as $YR_L^{'} = YR_L^i + \Delta YR_L + \Delta YG_L + \Delta YB_L + \alpha(YG_R^i + \Delta YR_R + \Delta YG_R + \Delta YB_R)$. Finally, we can obtain the crosstalk information when the counterpart image on the panel is green by subtracting $YR_{L,\mathrm{step1}}^{'}$ from $YR_{L,\mathrm{step2}}^{'}$. In this case, the crosstalk is $\alpha YG_R^{\,i}$. Thus, conventional crosstalk model should be modified to $Y_L^{'} = Y_L + \alpha Y_R^i$, $Y_R^{'} = Y_R + \alpha Y_L^i$. The cases of the X and Z tri-stimulus values are similar to the Y tri-stimulus value.

We used 24 inch FHD IPS stereoscopic LCD panel and polarizer glasses. The measuring distance and the ambient luminance were 50 cm and 0 lux, respectively. In this condition, $\alpha X'$, $\alpha Y'$, and $\alpha Z'$ were the 0.2544, 0.2522, and 0.2658, respectively. Following test pattern was used for experiments. 1. Left image: fixed green image (gray level 32). 2. Right image: yellow image varies from 0 to 255. Figure 1(c) shows the chromaticity coordinate, x and y, with and without crosstalk. In Fig. 1(c), the yellow and black rectangular dot represent the measurement x and y with/without crosstalk, respectively. The blue and red lines represent the results from the proposed and conventional model, respectively. As shown in Fig. 1(c), the proposed method can accurately predict the crosstalk regardless of counterpart images.

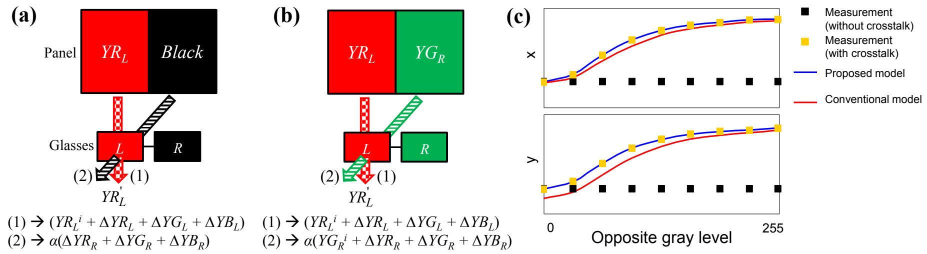

Fig. 1. Conceptual images (a) without and (b) with crosstalk. (c) Chromaticity coordinates, x and y

Acknowledgment

This work was supported by the ICT R&D program of MSIP/IITP[10041416, The core technology development of light and space adaptable energy-saving I/O platform for future advertising service].

References

1. Y. Kwak et al., "Crosstalk characterization method for stereoscopic three-dimensional television," *IEEE Trans. Consum. Electron*., vol. 58, no. 4, pp. 1411-1415 (2012).
2. J. M. Kim et al., "A novel method to accurately predict color information of liquid crystal displays with light leakage from black pixels," *J. Disp. Technol.,* vol. 9, no. 3, pp. 162-169 (2013).