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Horizontal and vertical triple-view display by use of three-layered LCD panels

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1. Introduction

Optical information processing enables limitation of viewing positions of information display [1-3]. In this paper, we propose a novel triple-view display technique that provides different information in horizontally and vertically three directions. In this paper, three-layered LCD panels are used for polarization processing. Use of three LCD panels is expectedly to enable triple views display without degrading the resolution.

2. Pixel arrangements to provide triple views

Fig. 1 shows the structure of the display which enables triple views in horizontal and vertical directions. When binary images are displayed on the three LCD panels, XOR (exclusive or) operations of pixel values are performed based on the polarization modulations of the three LCD panels.

Pixel values of the displayed images in a position (*k, l*) on the rear, the middle, and the front LCD panel are expressed by $r_{k,l}$, $m_{k,l}$, and $f_{k,l}$, where

$$r_{k,l}, m_{k,l}, f_{k,l} \in \{0,1\} \quad (1)$$

When the display is observed from left-hand side, in the (*k*-1)-th pixel in the front LCD, in *k*-th pixel in the middle LCD, and in the (*k*+1)-th pixel in the rear LCD are overlapped, and a pixel value $L_{k,l}$ is represented. In the situation shown in Fig. 1, represented pixel values at the central and the upper viewing positions, denoted by $C_{k,l}$ and $U_{k,l}$, depend on the overlapped pixel values. Thus, these represented pixel values are obtained by

$$L_{k,l} = r_{k+1,l} \oplus m_{k,l} \oplus f_{k-1,l}, \quad (2)$$

$$C_{k,l} = r_{k,l} \oplus m_{k,l} \oplus f_{k,l}, \quad (3)$$

and

$$U_{k,l} = r_{k,l+1} \oplus m_{k,l} \oplus f_{k,l-1}. \quad (4)$$

Note that $\oplus$ expresses XOR operation. In order to reproduce the desired pixel values of the triple views, $r_{k,l}$, $m_{k,l}$, and $f_{k,l}$ must maintain Eqs.(2)-(4) simultaneously. By alliance of these 3 formulas, the modulations in the three LCDs are derived.

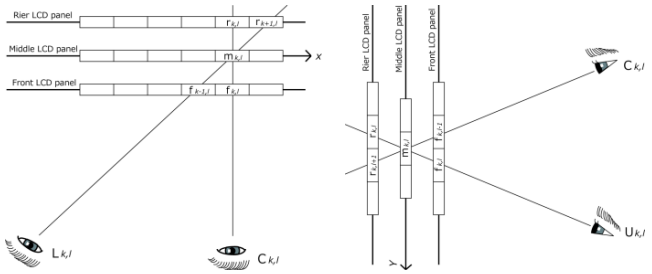

Fig. 1. Structure of 3-layered display and pixel arrangements for horizontal and vertical triple views.

3. Experiment

Fig.2 shows displayed images which enables the proposed triple views. Note that black and white correspond to pixel values of 0 and 1, respectively. Sizes of the pixel of the middle LCD and the rear LCD are set to 1.02 times and 1.04 times as large as the size of the pixel on the front LCD. The ratios depend on the gaps between LCD panels and the viewing distance. The pixel values in the observed images depends on the pixel values of display images. Pixel values in the three LCD panels are determined based on the above-mentioned formulas. Viewed images at the three positions are shown in Fig. 3. Viewed images from the left and the center in the lower direction represent L and C, respectively. Viewed image at the center from the upper direction represents U. Thus, horizontal and vertical triple views were successfully realized by the three-layered LCD display.

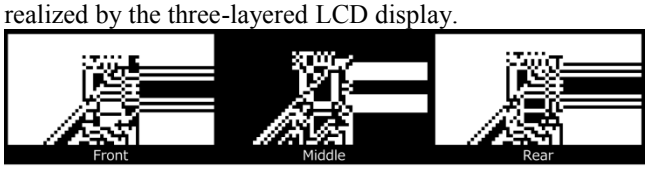

Fig. 2. Displayed images to provide triple views.

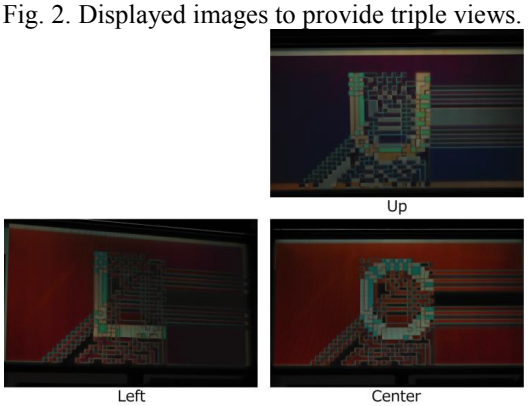

Fig. 3. Viewed images at the three viewing positions.

4. Conclusions

We have realized a polarization-modulation display by use of three-layered LCD panels. We designed for triple views in horizontal and vertical directions. Viewed images were observed from different three viewing positions that the left-hand side, the center part, and the upper part.

References

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