Invisible Two-dimensional Code Display for Additional Information

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Abstract. The authors have researched a support system of the reminiscence and life review activity. This support system consists of an interactive tabletop display and interface system. Many interaction systems are proposed until now. An invisible code is one of the useful technologies for a computer interaction. The invisible codes provide us with an operating environment using a pen-like device. However, this technology is applied to the only paper media. The authors think we want to realize an interaction using the invisible code on an electrical media. In this paper, we propose a method to display invisible codes using LCD panels and to detect a polarized symbol image with a conventional CCD camera.

Keywords: 2D code, group work, polarized invisible code, polarized light control, table-top display

1 Invisible Code Display

The printing technology using a special pigment enables us to provide a publication embedded with invisible codes. This technique is useful for developing an interaction system. We want to make good use of invisible codes at an electric display as well as a paper. To display visual information and to embed invisible additional information, the display panel needs to hide code symbols so as not to interfere with screen viewing as shown Fig. 1. So we utilize a polarized symbol image to overlap additional information on the visual screen. The polarized light wave has a useful characteristic to generate hidden images. You know you cannot perceive digits of a calculator if a polarizer is removed from an LCD, *i.e.*, it is impossible for human's eyes to distinguish characteristics of polarization. In our interaction display system using LCD panels, we utilize characteristics of polarization. As shown in Fig. 2, our proposed display system consists of a conventional LCD panel, an additional liquid crystal (LC) layer and some optical elements. LC layers can rotate the direction of the polarization axis according to the applied voltage. The LC layer sandwiched between both polarizers displays visual information. This structure functions as an LCD panel. Then this LCD panel emits the polarized light due to the existence of a surface polarizer (it is called an analyzer). Moreover, the overlaid additional LC layer changes the direction of polarization from LCD outputs. This LC layer generates invisible symbol patterns. A 1/4 wave plate is used to turn-

polarized light into circularly polarized light and vice versa as shown in Fig. 3. The final LC layer and this 1/4 wave plate output left or right circular polarized light waves. This difference of rotating direction makes a binary symbol image. As humans cannot perceive differences of polarization, they directly watch only visual images on the viewscreen without perceiving symbol patterns.

(a) view of normal camera (b) thru horizontal polarizer (c) thru vertical polarizer

Fig. 1. Invisible display unit

At the detection, the polarized symbol pattern images are observable through the 1/4 wave plate and the polarizer because the combination of these optical elements blocks the wave or not as shown in Fig. 4. This enables a camera to detect the invisible code on the display panel. Humans and cameras can perceive the hidden pattern through these optical elements. So the display panels show visual images and invisible symbols simultaneously. Human's eyes can get only visual information and a code reader finds an only binary symbol pattern.

To simplify optical techniques, Fig. 5 shows an illustration in which a structure involves no 1/4 wave plate. This figure clearly shows the basic concept of an invisible code display. The additional LC layer turns the linear polarization from LCD outputs. We can perceive the difference of polarization using a polarizer. Assume that the polarizer rotates 90 degrees. Then the direction of polarizer converts vertical into horizontal or vice versa. This means that a detector gets an inverse image which is white and black reversed. If the polarizer rotates 45 degrees, the detector perceives no information. A 1/4 wave plate can solve this problem. The 1/4 wave plate can cancel this direction dependence. Using this invisible code, the display system provides all users with visual information and assistance like an audio guide if the user needs a support and it can realize the adaptive interface.

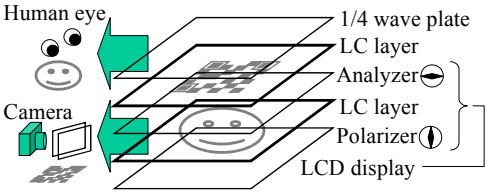

Fig. 2. Principle of generating invisible code

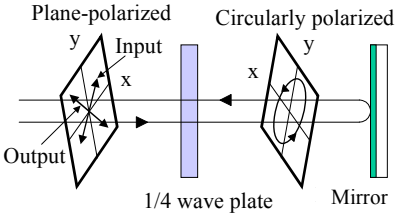

Fig. 3. 1/4 wave plate

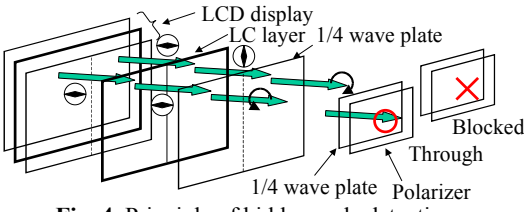

Fig. 4. Principle of hidden code detection

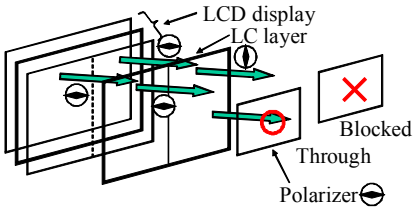

Fig. 5. Basic technology