Autostereoscopic Time Multiplexed 2D/3D Display

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Abstract

We have developed a 2D/3D time sequential LCD autostereoscopic display, which is capable of simultaneous displaying 2D and 3D graphics at a frame rate up to 120 Hz. Left and right sets of viewing zones are formed by a combination of a fast LC shutter and a lenticular lens array.

1. Introduction

An application of modern autostereoscopic display is 2D/3D compatibility. This requirement appeared mostly because of the fact that space multiplexed 3D displays are unable to display 2D images with full resolution of the image panel. During the last decade a number of viable design solutions of 2D/3D switchable displays have been found. There are two ways to provide both 2D and 3D operation in autostereoscopic display. One way is to make 2D/3D reconfigurable space multiplexed display sacrificing the resolution in 3D mode and getting full resolution in 2D mode [1, 2].

Another way is to make time-multiplexed display capable of displaying full resolution 3D image [3]. Since time-multiplexed display displays left and right images in a sequence, the resolution of 3D image can be the same as the resolution of 2D image that makes 2D/3D switching virtually unnecessary. It can be expected that such display is capable of displaying 2D and 3D applications simultaneously without loss of resolution. 2D/3D switchable display also can be provided with such option, however the dedicated area for 3D image should be chosen by the switching of specially arranged electrodes [4].

In contrary, time multiplexing display does not require any switching so that 2D or 3D mode of visualization is just defined by the content and has no restrictions on size of 3D window or its position on the screen and even can be moved by mouse dragging

2. Experimental Setup

We have developed an autostereoscopic 2D/3D display by used a commercial TN LCD monitor.

Fig.1 shows optical principle of viewing zone formation. Each lens of lenticular array acts in horizontal plane as an objective of image projector thus producing image of vertical retarder strips at the viewing distance of 700 mm. These images serve as exit pupils of the directional backlight. The output surface of the lenticular array is uniformly illuminated thus representing a good backlight for the LCD panel.

Before the light rays, emitted by the backlight and polarized by the polarizer reach the input polarizer of LCD they pass through three anisotropic elements.

Depending on the status of the LC shutter the input polarizer of LCD panel blocks the light passes through odd or through even strip of microretarder in accordance with the stripe retardance.

The elements of micro-retarder array are shaped as thin vertical stripes having alternatively half-wave and zero retardance. The retarder film on glass substrate has been manufactured using the technology, providing the absence of any gap between the retarder strips in order to provide seamless formation of viewing zone.

Work of micro-retarder array and polarization switch, placed between crossed polarizers is illustrated by the microphotograph as shown in Fig.2. The upper part of the photo shows the microretarder itself while in the lower part the additional half wave film is inserted between crossed polarizers. A pi-cell, used as a polarization switch, plays the role of switchable retarder. In fact the micro-retarder together with polarization switch work as a switchable slit mask having opaque regions and transparent slits.

For instance if the summarized phase shift through the LC shutter 0 and quarter-wave film is equal to quarter wave the light, passed through odd stripe of microretarder having plus quarterwave retardance is blocked while the light passes through the even stripes of micro-retarder having minus quarter wave phase shift passes through the polarizer. Switching the LC shutter from zero retardance to minus half-wave retardance blocks the light passed through the even stripes of micro-retarder.

The resulted light distribution in right channel at the viewing distance measured in experiment is shown in Fig.3 by solid line. Dashed line in the diagram represents joint left-right channel distribution of light.

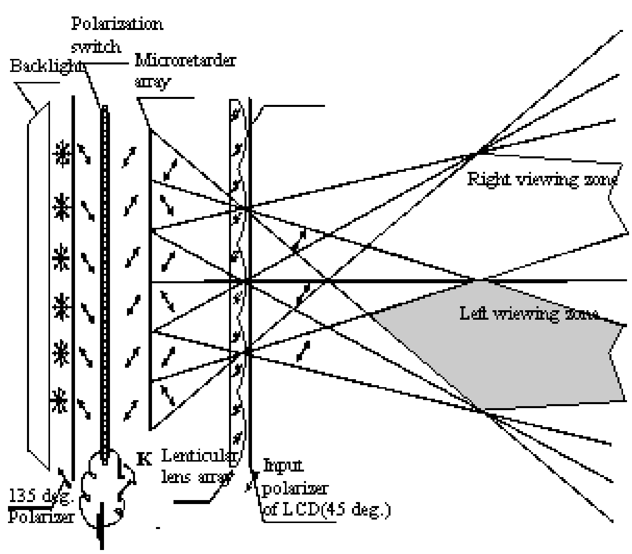

Fig. 1. Viewing zone formation by directional backlight

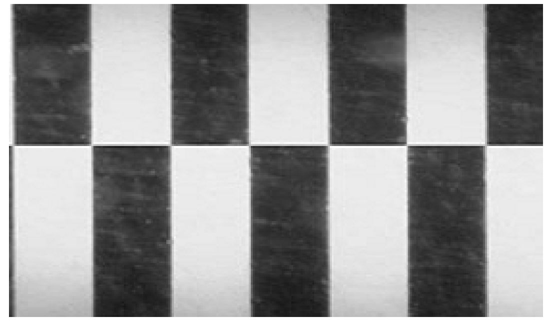

Fig.2 Appearance of microretarder array in crossed polarizers.

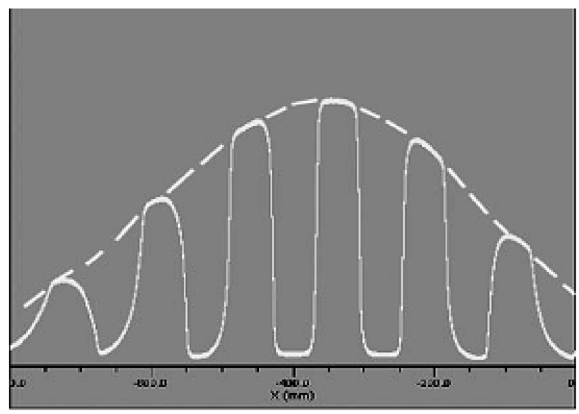

Fig.3 Light distribution at a viewing distance

3. Results and discussion

The display is capable of displaying both 2D and 3D images with very low crosstalk as shown in Fig. 4 ~ Fig 6.

In the time multiplxed display, time dependent crosstalk is critical occurred by several sources. It can take different values in different moments of time and in different parts of LCD screen. We shall describe as a dynamic crosstalk with a help of time-space updating diagram shown in Fig.4.

The updating moments of each line in the LCD display form a slanted line in the diagram. The updating process begins from the upper line in the top of screen and ending in the bottom line. Each line keeps the values of pixels luminance up to the next update moment. First type of the dynamic crosstalk is a time-mismatch crosstalk appearing because of the time mismatch between the moment of image update and the moment of switching polarization switch. To reduce time mismatch crosstalk polarization switch should have number of individually switchable segments.

Another source of dynamic crosstalk is too long response time of LCD pixels. This kind of crosstalk appears in the beginning of refresh cycle in each line gradually decreasing within the response time of the LCD panel. The declared response time of the panel, applied in the display, is about 3 ms with RTA (Rise Time Acceleration) and it can be expected that the crosstalk is high within 3 ms from the beginning of refresh cycle. The corresponding area in the diagram is hatched vertically. It is shown that RTA technique, developed for motion blur reduction is capable of crosstalk cancellation6. A conventional setting of the RTA levels provides cancellation of the crosstalk at the refresh rate 60 Hz. To prevent image flicker the refresh rate of the autostereoscopic display should be increased up to 100-120 Hz that requires corresponding adjustment of RTA levels. The controller of LCD display has been modified to support 100 and 120 Hz refresh rate however at the time of the display development we were unable to modify settings of RTA circuits. Although RTA was unable to completely cancel crosstalk at a high frame-rate, the crosstalk has been greatly reduced by using RTA. It should be remembered that RTA and other overdrive techniques unable to compensate rise/falling time in transitions to the maximum brightness level and to the minimum brightness level, i.e. saying “crosstalk cancellation” we can only consider medium contrast images.

2D images can be seen without any restrictions of viewer’s position while to see full screen orthoscopic 3D images viewer should keep the optimum distance from screen and proper head position. Stereoscopic image can be displayed either in a full size window or in a smaller size dragging window.

The smaller is the window the greater is the viewer’s freedom in z dimension. The display is characterized with low crosstalk between left and right channels.

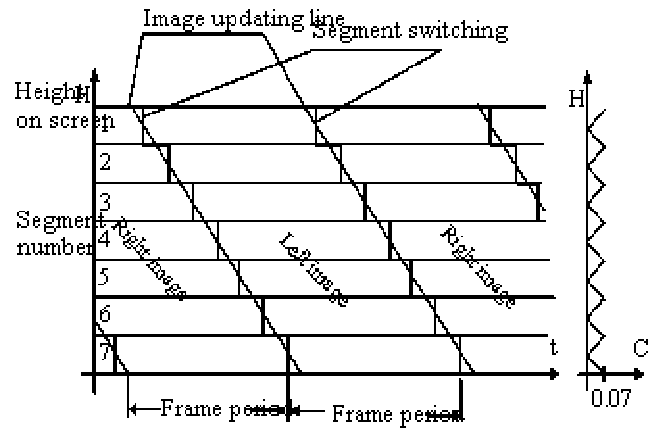

Fig.4 Time-Height diagram of switching segmented polarization switch and corresponding Crosstalk-height diagram

Fig.5 Low crosstalk image

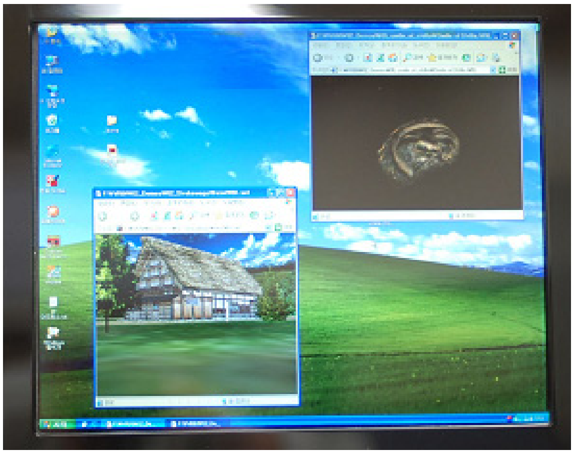

Fig.6 Appearance of the autostereoscopic display screen with two different stereoscopic applications on 2D windows desktop

4. Summary

A 2D/3D time sequential LCD autostereoscopic display is fabricated and showed possibility of simultaneous displaying 2D and 3D graphics by using a commercial LCD panel despite its slow pixel response rate.

5. References

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