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Wu-Xiang Zhao [a], Qiong-Hua Wang [a], Da-Hai Li [a] & Yu-Hong Tao [a]

[a] School of Electronics and Information Engineering, Sichuan University, Chengdu, China

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Pixel Arrangement of Autostereoscopic Liquid Crystal Displays Based on Parallax Barriers

Wu-Xiang Zhao, Qiong-Hua Wang, Da-Hai Li, and Yu-Hong Tao
School of Electronics and Information Engineering,
Sichuan University, Chengdu, China

The methods of pixel arrangement for autostereoscopic liquid crystal displays based on conventional vertical parallax barriers are summarized. A novel method of pixel arrangement for autostereoscopic liquid crystal displays based on step parallax barriers is proposed. The pixel arrangements are given for different inclined angles of parallax barriers and different column numbers of images. A demo of the autostereoscopic liquid crystal display using the new method of pixel arrangement presents very good stereo images. The results help to solve the process, storage and transmission of stereo images of autostereoscopic liquid crystal displays based on parallax barriers.

Keywords: autostereoscopic display; liquid crystal display; parallax barrier; pixel arrangement

PACS Numbers: Codes 42.30.-d

I. INTRODUCTION

Nowadays, many kinds of autostereoscopic liquid crystal display devices have been developed. But the one main optical technology for autostereoscopic liquid crystal display is parallax barriers. The autostereoscopic liquid crystal display consists of a flat panel liquid crystal display and parallax barriers; the two parts couple precisely. The autostereoscopic liquid crystal display based on parallax barriers has superior characteristics and provides the low cost necessary for mass-market adoption and it has the ability to switch between 2D

Address correspondence to Wu-Xiang Zhao, School of Electronics and Information Engineering, Sichuan University, 1st Ring Road, Chengdu 610065, China. E-mail: qhwang@scu.edu.cn

display mode and 3D display mode. The approach can also produce high quality 3D displays utilizing either two views or multiple views for extended viewing freedom [1–3].

The image for each view in multiple view autostereoscopic displays are called parallax image. All parallax images are composed into a composed image displayed on the liquid crystal display. The paper will present the pixel arrangement methods of parallax images. They are important to the development of multiple view autostereoscopic liquid crystal displays based on parallax barriers, and help to solve the process, storage and transmission of 3D images.

II. PRINCIPLES OF AUTOSTEREOSCPIC LIQUID CRYSTAL DISPLAY BASED ON VERTICAL PARALLAX BARRIERS

Figure 1 illustrates a basic autostereoscopic liquid crystal display based on conventional vertical parallax barriers. The structure and principle of the autostereoscopic liquid crystal display are shown in Figure 1(a) and the pixel arrangement diagram of the autostereoscopic liquid crystal display is shown in Figure 1(b). There are two composed images (view number $N = 2$) in the display. One composed image (L) is for left eye and the other composed image(R) is for right eye. When $N > 2$, the principle of autostereoscopic liquid crystal displays is the similar to the situation when $N = 2$.

In the pixel arrangements of autostereoscopic liquid crystal displays based on vertical parallax barriers, the horizontal periods of parallax barriers are close to the integral number times of the pixel width, Therefore colorful moiré stripes are obvious on the display

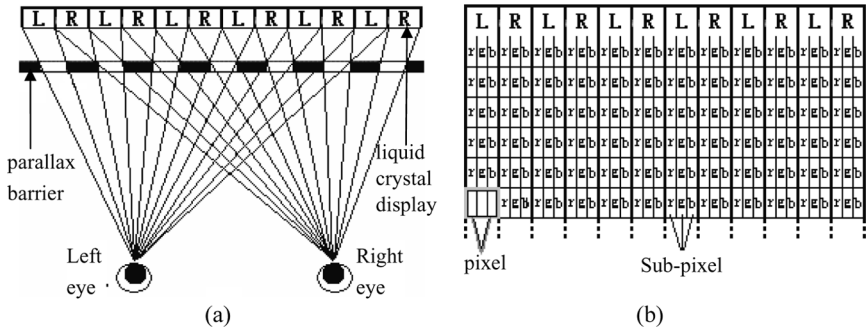

FIGURE 1 The diagram of an autostereoscopic liquid crystal display based on vertical parallax barriers. (a) The structure and principle of the display. (b) The pixel arrangement of the display.

screen. Some measurements can be taken to eliminate the colorful moiré stripes, for example, sub-pixel arrangements of parallax images when $N \neq 3$. But there are still some disadvantage such as the unreasonable decrease of horizontal resolution and vertical resolution of the parallax images, resulting in the abnormal proportion between horizontal and vertical resolution of the composed images. Hence, to avoid these disadvantages of vertical parallax barriers, we propose an autostereoscopic liquid crystal display based on step parallax barriers.

III. PIXEL ARRANGEMENTS OF AUTOSTEREOSCOPIC LIQUID CRYSTAL DISPLAYS BASED ON STEP PARALLAX BARRIERS

Figure 2 shows a four-view autostereoscopic liquid crystal display based on step parallax barriers. An array of step parallax barriers are shown in Figure 2(a) where A is an inclined angle, and $\tan(A) = 1/3$. Figure 2(b) shows the composed image matrix of a four-view image and Figure 2(c) shows the first view image that an eye sees through the step parallax barriers. The second view, the third view and the fourth views are seen when viewers' eyes move from the right to the left. Therefore the display can demonstrate multi-view stereo images.

In the pixel arrangements of autostereoscopic liquid crystal displays based on step parallax barriers, the colorful moiré stripes do not exist on the display screen because the horizontal periods of parallax barriers are not close to the integral number times of the pixel width. Moreover both the horizontal resolution and the vertical resolution of the parallax images decrease simultaneously, resulting in the

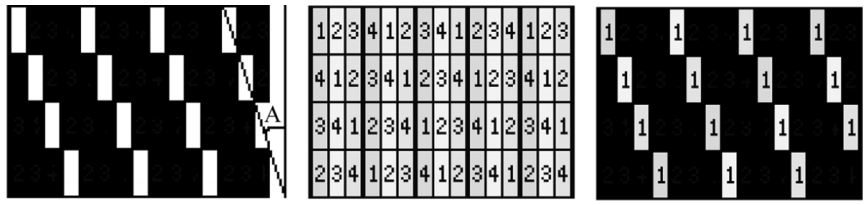

FIGURE 2 The diagram of an autostereoscopic liquid crystal display based on step parallax barriers. (a) An array of step parallax barriers. (b) The composed image matrix of the display. (c) The first view image of the composed image matrix seen through the step parallax barriers.

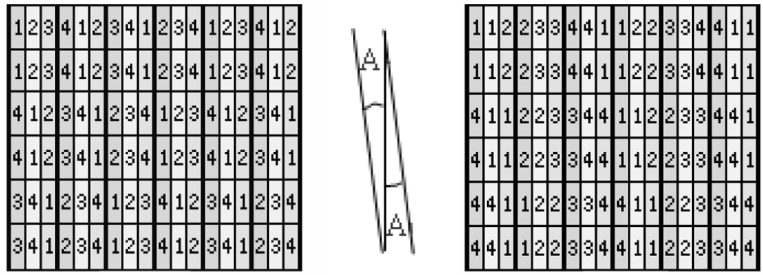

FIGURE 3 The pixel arrangements of 4-view autostereoscopic liquid crystal displays using step parallax barriers with $\tan(A) = 1/6$. (a) 1 column sub-pixels and (b) 2 column sub-pixels.

rational proportion between horizontal and vertical resolution of the composed images.

The pixel arrangement shown in Figure 2 is for single column sub-pixels. Of course, there are 2, 3 and other numbers of column sub-pixels arrangements for many kinds of autostereoscopic liquid crystal displays. Figure 3 shows two types of pixel arrangements of 1 column and 2 column sub-pixels when $\tan(A) = 1/6$, and $N = 4$.

IV. EXPERIMENTS OF COMPOSED IMAGES ON A DEMO OF AUTOSTEREOSCOPIC LIQUID CRYSTAL DISPLAY

We developed a 15-inch autostereoscopic liquid crystal display demo based on step parallax barriers using the above pixel arrangement methods. It is a 4-view autostereoscopic liquid crystal display with

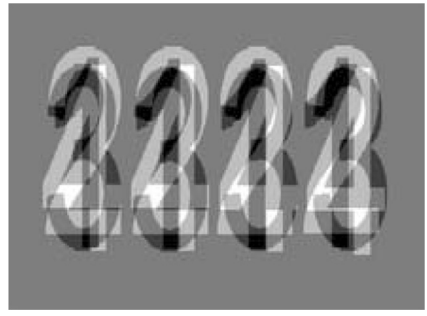

FIGURE 4 A 4-view composed image displayed on the autostereoscopic display with 2-column sub-pixels and $\tan(A) = 1/3$.

(a) (b) (c) (d)

FIGURE 5 The pictures taken by a camera located in 4 positions along a horizontal line paralleling to the parallax barriers. (a) 1st pictures from the right, (b) 2nd picture from the right, (c) 3rd picture from the right, and (d) 4th picture from the right.

2-column sub-pixels and $\tan(A) = 1/3$. The 4 parallax images are represented by black '1' with white background, white '2' with black background, black '3' with white background and white '4' with black background. The 4-view composed image from the 4 parallax images is shown in Figure 4.

The pictures taken by a camera located in 4 positions along a horizontal line paralleling to the parallax barrier are shown in Figure 5. These pictures match parallax images correctly. 4 parallax images are composed into a composed image which is shown on the demo of the autostereoscopic liquid crystal display, and viewers see a stereo image.

V. CONCLUSION

The pixel arrangement methods of autostereoscopic liquid crystal displays based on conventional vertical parallax barriers are summarized. The pixel arrangement methods of autostereoscopic displays based on step parallax barriers are proposed and analyzed. The pixel arrangements are given for different inclined angles of parallax barriers and different column numbers of images. A demo of the autostereoscopic display using the pixel arrangement method presents very good stereoscopic images. The results help to solve the process, storage and transmission of stereoscopic images. For example, the images cannot be processed by compressing neighboring pixels because of the arrangements of sub-pixels of composed images and therefore new methods are under way.

REFERENCES

[1] Wang, Q. H. (2007). 3D autostereoscopic liquid crystal display based on lenticular lens. *Proc. of Asia Display*, *1*, 453.
[2] May, P. (2003). Reconfigurable2-D/3-D displays. *Information Display*, *19*, 26.

[3] Lee, H. J., Nam, H., Lee, J. D., Jang, H. W., Song, M. S., Kim, B. S., Gu, J. S., Park, C. Y., & Choi, K. H.. (2006). A high resolution autostereoscopic display employing a time division parallax barrier. *SID Symposium Digest*, *XXXVII*, 81.
[4] Wang, Y. Q. (1998). Computer-procession principle and realization of autostereoscopic images. *Journal of Anhui Institute of Mechanical & Electrical Engineering*, *13*(4), 39.
[5] Son, J., Saveljev, V. V., Chung, S., & Cha, K. (2005). Full parallax image generation with a single viewing zone forming optics. *Proceedings of IDW/AD '05*, *1*, 1781.
[6] Wang, A. H., Wang, Q. H., & Li, D. H. (2008). Three dimensional display technology. *Electronic Devices*, *31*(1), 299.