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Ground autostereoscopic display with new type non-uniform barrier

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ABSTRACT

This paper analyzes the drawbacks of traditional parallax barrier with the uniform slits for large-scale ground autostereoscopic display firstly. And then an approach of designing non-uniform barrier for ground display is proposed by use of the reverse ray-tracing technique and Iterative approximate algorithm. Form the numerical simulation, it is proved that low cross-talk feature of the non-uniform barrier is an advantage relative to traditional parallax barrier.

1. Introduction

Autostereoscopic displays provide depth perception without observers having to wear special glasses. A wide variety of these displays have been devised over the past several decades, such as Integral imaging display, Parallax-based display. But they all provide three-dimensional (3D) display in the front of screens which are in parallel with the walls, and the sense of immersion is decreased. Many research institutes try to design autostereoscopic displays for tabletop [1–4]. However, the displays devices cannot be compatible with the traditional autostereoscopic display images [5]. So this paper presents a nine-view large size ground autostereoscopic display and its associated barrier generating methods based on reverse ray tracing technique [6,7].

In this paper we will introduce the hardware configuration of the autostereoscopic ground display and analyze the drawbacks of traditional parallax barrier with the uniform slits by first. We find that the traditional parallax barrier is not suitable for ground display and then propose the non-uniform barrier slits generating method. At end, the simulation result is to illustrate the effectiveness of the non-uniform barrier.

2. System hardware structure of ground auto-stereo displays

As depicted in Fig. 1, our ground display system is composed of one sever, four PC clients and four special autostereoscopic displays. Sever and PC clients are connected by the local network. According to the computer graphic, the model-view matrix of the server's virtual camera is sent to the virtual camera of PC clients and each PC client can calculate its own model-view matrix by observer's eye position [8]. The four autostereoscopic displays by using non-uniform slits barrier is different from the traditional parallax barrier.

3. The drawbacks of traditional parallax barrier with the uniform slits

In the design process of traditional parallax barrier with the uniform slits, it is exclude to consider the impact of the refractive index n_i and the angle of incidence θ. As the arrangement of sub-pixels for nine-viewpoint autostereoscopic display in LCD panel is depicted in Fig. 2, the eye of observer would see the error sub-pixel with the increase of $\boldsymbol{x}$ or $\boldsymbol{y}$. When the distance between S_n and S_r is more than one pixel length, the cross-talk will appear.

If the traditional parallax barrier auto-stereoscopic display is applied to show ground 3D scene, Fig. 2 is the simulation result by the use of Ref. [5] approach when the eye position is (0, 0, 2.5 m). Table 1 is to show the simulation parameters which have the same physical meaning as in Ref. [6].C_{lt}, C_{rt}, C_{rb}, C_{lb} represent the center position of the four LCD screens. As is depicted in Fig. 3, the cross-talk is very serious because it is hard to find a complete viewpoint image for the observer. Therefore, traditional parallax barrier with

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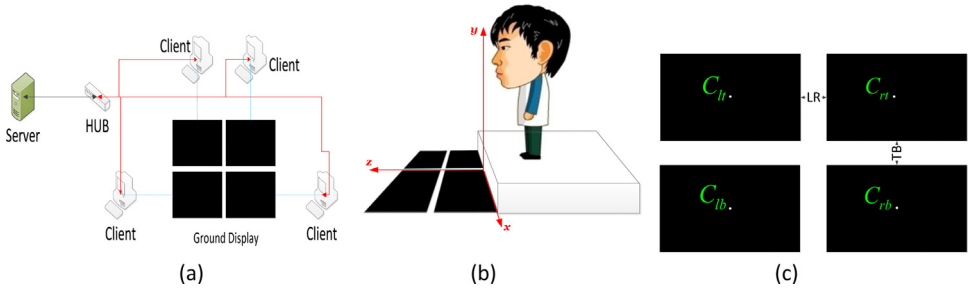

Fig. 1. Ground auto-stereo display system: (a) the system hardware structure: Four PC clients output 3D stereo image to each ground display LCD screen by receiving server's commands. (b) The coordinate system for the display system. (c) The center of four autostereoscopic displays and the gap LR, TB between them.

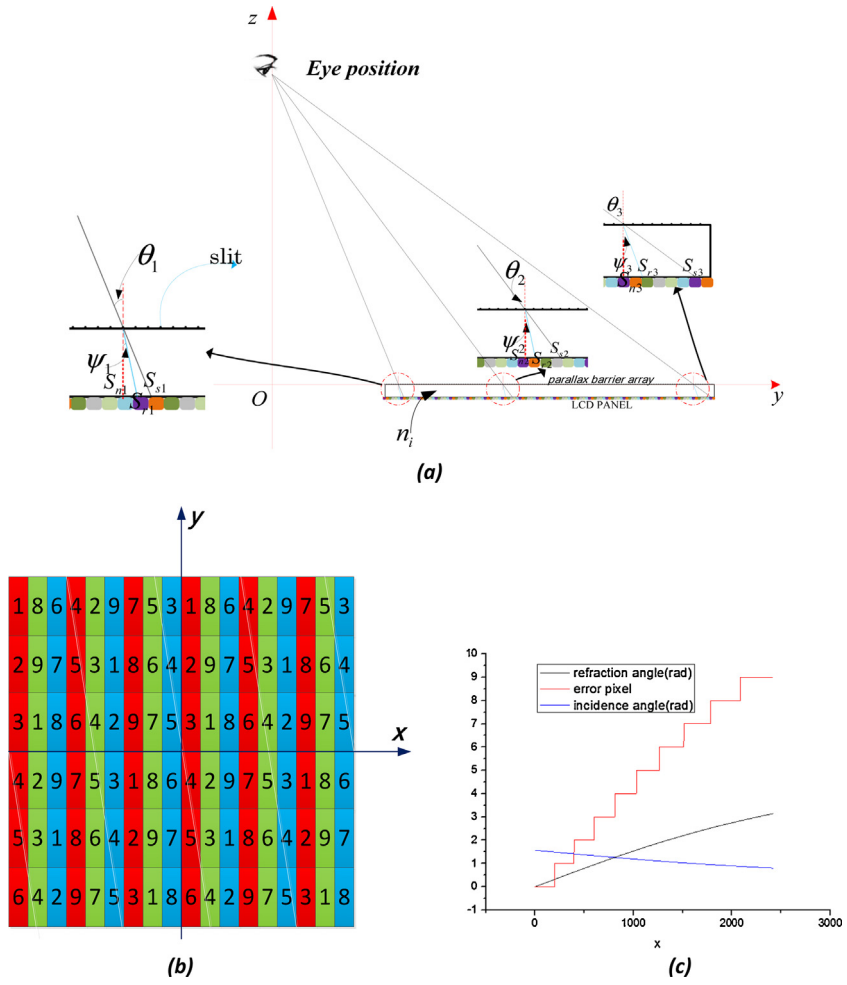

Fig. 2. Error pixels caused by traditional parallax barrier without considering n_i and θ: when x is equal to 0, each slit's position have different refraction angle θ and may caused observer to get the error view zone sub-pixels. (b) The LCD-panel sub-pixels and traditional slits arrangement. (c) With the increase of slit positions' y value, the distance between start point S_n and error start point S_r will be increased.

the uniform slits have the obvious drawbacks for grounds auto-stereoscopic display.

4. The approach of designing non-uniform parallax barrier for ground display

Assumed that the light ray emitted from a starting point S within the LCD panel is incident to a crossing point C_r on the interfacing surface and that the light ray is transmitted from the crossing point C and reaches the position of the observer's eye E, as shown in the Figs. 4 and 5. If the starting point S and eye E have a given value, the value of crossing point C_r is existence and uniqueness according to Fermat's theorem. The relationship between crossing point C_r, the observer's eye E and starting point S can be expressed as in the following equation [6]: