Auto-stereoscopic 60 view 3D using slanted Lenticular lens array

Hee-Jin Im*, Byung-Joo Lee, Hyung-ki Hong** and **Hyun-Ho Shin
LG. Philips LCD, Anyang R&D center, Anyang-shi, Gyongki-do, Korea

Keywords: **Auto-stereoscopic, 3D, Super Multiview, Slanted Lenticular lens**

Abstract

Auto-stereoscopic 3D of 60-view number is made using slanted lenticular lens array and LCD of 15.1 inch diagonal size and 3200 by 2400 pixel numbers. Due to its large view number, smooth motion parallax is observed and the visual fatigue is reduced.

1. Introduction

Watching a natural three-dimensional image is considered by many people to be next-step in evolution of displays. In case of auto stereoscopic type 3D which requires no additional special eyeglasses, light distribution from each pixels are modified such that each eye of the viewer sees different images from the same display. This binocular disparity between left and right eyes makes the viewer perceive 3D images. In case of auto stereoscopic multi-view 3D using flat panel display, more than 2 different images are seen along the horizontal direction. The number of the total different images is known as view number and increase of view number has been known to provide motion parallax as well as binocular disparity and to reduce visual fatigue by moving viewers' head though jumping as the viewer moves from view window to view window.

Various methods had been reported to make multi-view 3D such as zigzag shaped barrier and slanted lens array.

Though 3D of view number such as 36, 72 had been reported, we think that design rule for very large view number is not well defined, as only limited number of prototype has been reported. With the increased view number and decrease between viewing zones, overlap between zones affects 3D image quality. We designed intentionally a 60 view 3D configuration, which would cause problem of color separation for 3D of small view number. And we checked how much this would affect 3D image quality by experimental result of our 3D prototype.

2. Experimental procedures

We require the new 3D display design condition for making auto-stereoscopic super multi-view 3D system to reduce visual fatigue and to provide motion parallax.

We designed auto-stereoscopic 60view 3D using lenticular lens array slanted angle of $\tan^{-1}(1/5) = 11.3^\circ$. Multi-view 3D using this slanted angle has not been reported.

In case of using 11.3° slanted lenticular lens array, each view contains only a kind of colors among three colors which are red, green and blue when we use stripe color filter type LCD panel.

If we use conditions where view numbers are repeated by multiple of 3 sub-pixels in horizontal direction, serious color separation is expected to occur in 3D display. But design rule of super multi-view is different from that of smaller view display.

But design rule of super multi-view is different from that of smaller view display.

We have to consider that color separation is observed not to occur and smooth motion parallax is provided, due to overlapping between viewing zones.

2.1 Getting 60-view Images

For 3D display, every view represents an image seen from slightly different direction. So we need 60 images for each view.

We can get 60-view images by using software or hardware like a camera

Cameras are located same distance from object to

show 3D image and equal to spaces between cameras. The space for preventing image flipping and providing motion parallax, a camera angle between one view and adjacent view is optimized.

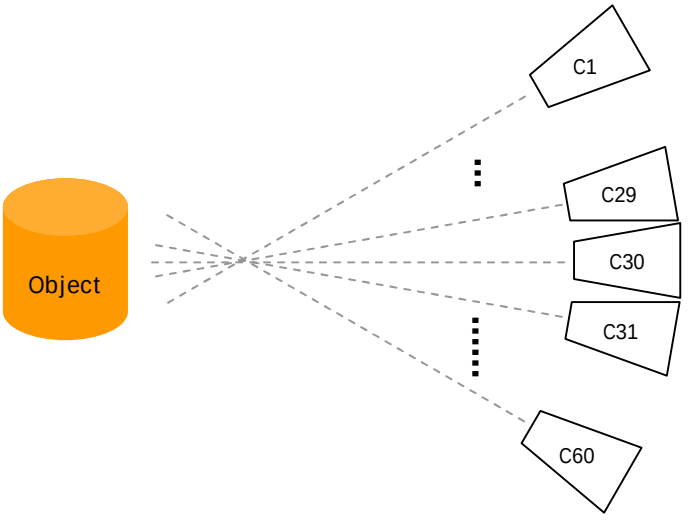
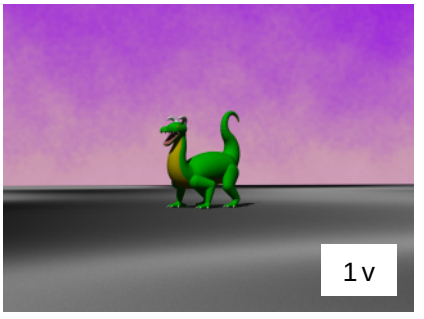


Fig1. Getting 60-view images



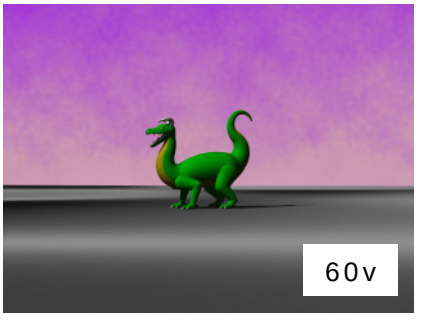


Fig2. Example 1-view image and 60-view image

After getting 60-view images, we made a 60-view 3D image by the repeat pattern consisted of 12 sub-pixels by 5 pixels. Figure 3 shows the repeat pattern. Each view arranges to the cycle of the repeat pattern and shift three sub-pixels in the horizontal direction and five pixels in the vertical direction. Because three sub-pixels is a pixel in strip color filter type LCD panel, slanted angle is $\tan^{-1}(1/5)$, and because of shift a pixel in the horizontal direction, a view represents a kind of colors.

Figure 3 shows repeat pattern. That size is in the ratio of 4 pixels to 5 pixels and therefore a view repeats in the horizontal direction about the same in the vertical direction.

So a view is an equitable distribution in the horizontal and vertical direction in a 60-view 3D image.

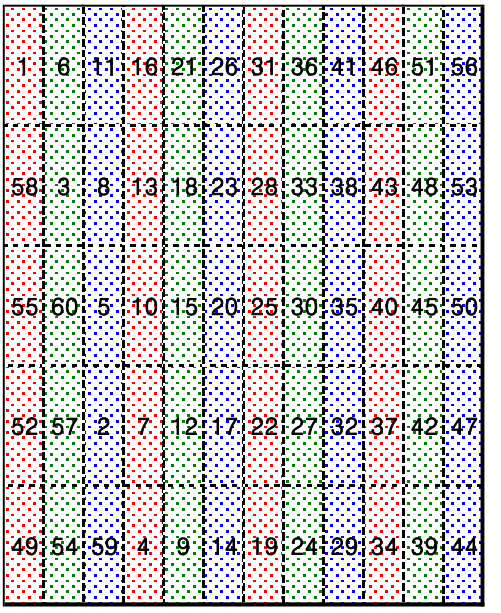


Fig3. Sup-pixel arrangement

2.2 Prototype 3D Display

Our new prototype of auto-stereoscopic super multi-view 3D system consists of a high resolution LCD panel and a slanted lenticular lens array sheet.

We made auto-stereoscopic 60-view 3D system using slanted lens array and LCD of 15-inch diagonal size and 3200 by 2400 pixel numbers. Slanted lens sheet is attached in front of LCD.

Figure 4 shows the lens configuration and arrangement of sub-pixels where number denotes zones assigned to each sub pixel. Each zone includes one type of color among red, green and blue colors. And a view is shown an equitable distribution in the horizontal and vertical direction in a 60-view 3D image.

Detailed specifications are listed in Table 1. 3D resolution is represented as 3200 by 2400 divided 12 by 5, though perceived 3D resolution is higher.

Table 1. Specification of 3D display

2D LCD Size	15.1”
2D Resolution	3200 x 2400
3D Resolution	266 x 480 (cal.)
Sub-pixel Size	32 x 96 ㎛
Angle of Slanted Lens	$\tan^{-1}(1/5) = 11.3^{\circ}$
Number of Views	60views

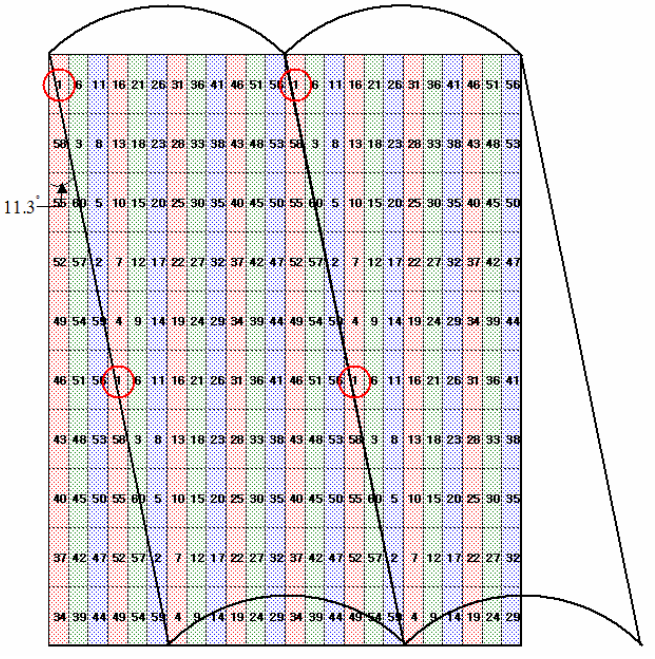


Fig4. Lens Configuration

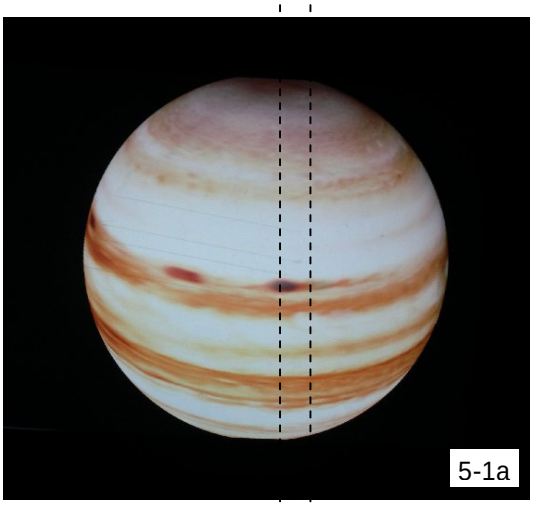
3. Result

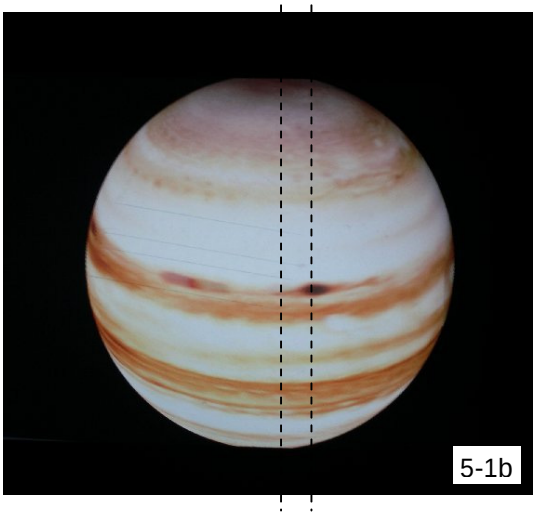
Figure 5 shows two 60view 3D images by our prototype captured at different horizontal positions and directions.

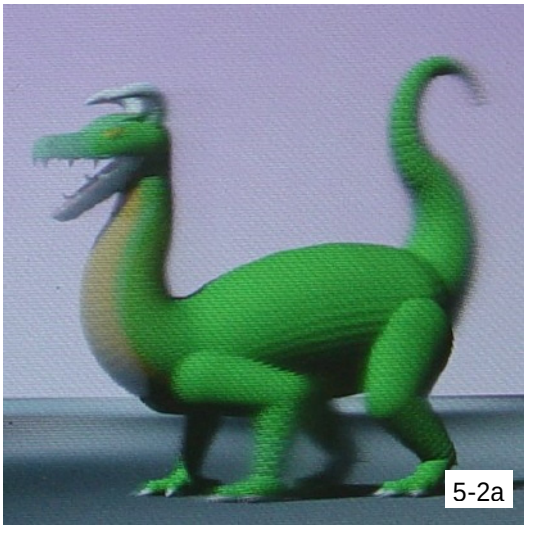
The position of the Red spot in Jupiter is continuously changed by the different view directions in Figure 5.

Furthermore when we saw the image of green dragon, the green dragon was shown like moving its body, legs and tail by moving our head

In result of our prototype, smooth motion parallax is observed. Also any serious color separation is not observed.







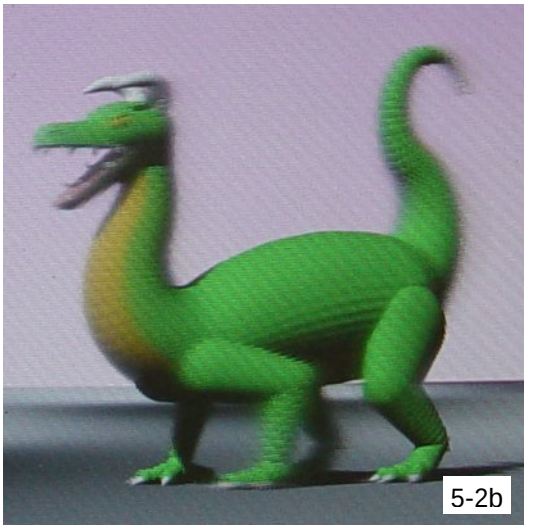


Fig5. An example of two 60-view 3D images captured at different horizontal positions and directions
5-1: The 3D image of Jupiter
5-2: The 3D image of green dragon

4. Discussion

Design rule for larger view number seems different from that of smaller view number such as 2 and 9. Prevention of color separation has been known to be one key design consideration for auto-stereoscopic 3D of view numbers.

However, as view number increases and zone distance becomes comparable or less than eyeball size, overlaps between viewing zones should be considered.

Though many design conditions of super multi-view 3D display have been reported, each viewing zone of 3D system including only one kind of colors had not been reported. 3D systems comprised of each viewing zone including all kinds of colors have to consider arrangement of each color. But our 3D system doesn't need to consider that. Even though each viewing zone of the proposed 3D system includes only one kind of color of three colors sub-pixels, natural overlapping between viewing zones seems to reduce problem of color separation. And sub-pixel arrangement repeat pattern for 60-view 3D size is in the ratio of 4 pixels to 5 pixels and therefore a view repeats in the horizontal direction about the same in the vertical direction, so a view is an equitable distribution in the horizontal and vertical direction in a 60-view 3D image. Because of that, 3D resolution decreases in the horizontal direction about the same in the vertical direction. That increases more perceived resolution than perceived resolution when decreased 3D resolution in the horizontal direction is different greatly from that in the vertical direction.

We think that this information can give us more freedom of design in determining the relation between sub-pixel and the corresponding viewing zone for multi-view display.

5. Conclusion

Many research results about auto-stereoscopic super multi-view 3D display have been reported, but the design rule for super multi-view is not well defined. We designed intentionally a 60 view 3D configuration, and we checked out that super multi-view 3D image by experimental result of our 3D prototype observed smooth motion parallax, also any serious color separation is not observed. The study of the design rule for super multi-view has been continuing to improve quality of super multi-view 3D image.

6. Acknowledgements

We thank colleagues of An-yang R&D center for providing LCD panel of ultra-high pixel density.

7. References

[1] B. Javidi and F. Okano, "Three-dimensional television video and display technologies", Springer, Berlin (2002)
[2] M. Watanabe, Y. Takaki, IDW, pp1547-1550 (2004)
[3] Y. Takaki, IMID, pp211-216 (2006)
[4] C. van Berkel, SPIE vol.3639, pp84-91(1999)
[5] L. Lipton and M. Feldman, SPIE vol.4660, pp229-235(2002)