SIMULATION OF IMAGE DISTORTON AND ITS CORRECTION BY OBSERVER'S ROTATION MOVEMENT IN STEREOSCOPIC DISPLAY

Dong-Wook Kim[1,2], Kwang-Hoon Lee[1], Eun-Young Chang[3], Jin Woong Kim[3], Sung-Kyu Kim[1]*

[1]Imaging Media Research Center, KIST, Seoul, Korea
[2]Department of Physics, Korea University, Seoul, Korea
[3]Broadcasting & Telecommunications Media Research Division, ETRI, Daejeon, Korea
E-mail: 21ap@kist.re.kr

ABSTRACT

Variation of viewing position of the observer is one of factors of image distortion in the stereoscopic display. A rotation movement of the observer makes the stereoscopic image distortion and that is caused by different horizontal position of each eye of the observer. It is different from horizontal and depth directional movement of the observer. In this paper, we showed the numerical simulation result about the distortion analysis and the correction of the stereoscopic image in rotation movement of the observer.

Keywords: stereoscopic display, image distortion, rotation movement, image processing

1. INTRODUCTION

To display correct image and relief of the eye fatigue of the observer, a removal of distortion in the stereoscopic display is needed. Variation of viewing position of the observer is one of the factors of the image distortion in the stereoscopic display. Only analysis of horizontal and depth directional movement of the observer has been considered in most existing papers.[1, 2] A depth directional movement of an observer leads to a compression and a expansion of the depth image and a horizontal movement of the observer leads to a tilted image. But horizontal and depth directional movement of the observer can not be the perfect distortion analysis and its correction.[3] Therefore, analysis of the rotation movement of observer is needed.

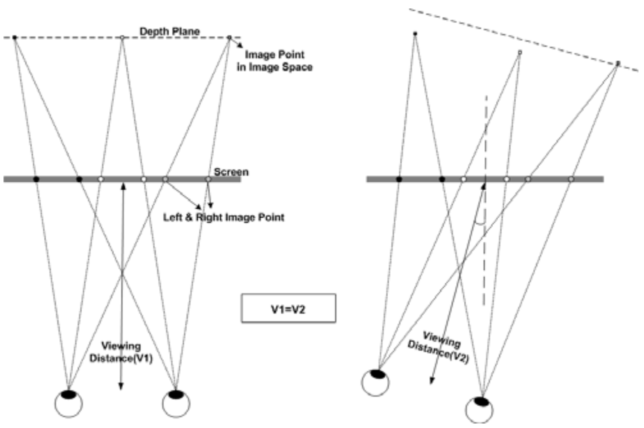


Fig. 1 Image distortion by rotation movement of the observer

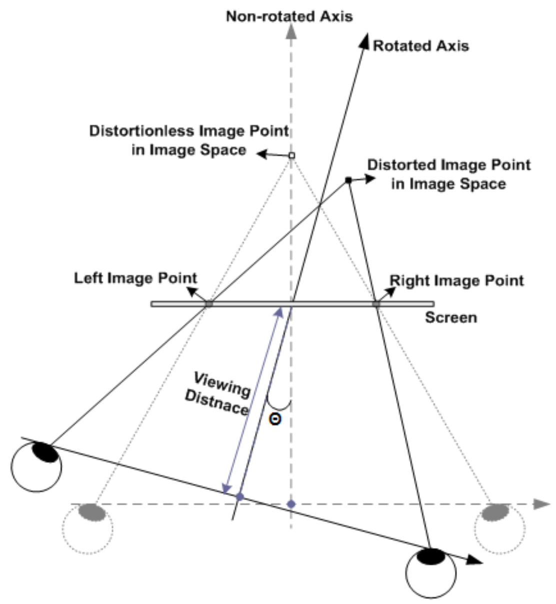
Figure 1 shows that the image distortion is made by rotation movement of the observer. The cause of this distortion is that observer feels an image parallax according to a rotation angle. In the figure 1, we can show that the rotation movement of the observer makes different image distortion, compared with observer's other movements which are depth directional and horizontal direction. So, a comprehension of its tendency is important.

In this paper, we confirmed the image distortion by rotation movement of the observer through simulation and analyzed width and depth distortion according to rotation angle. Also, we showed the corrected simulation result through its correction method in the stereoscopic display.

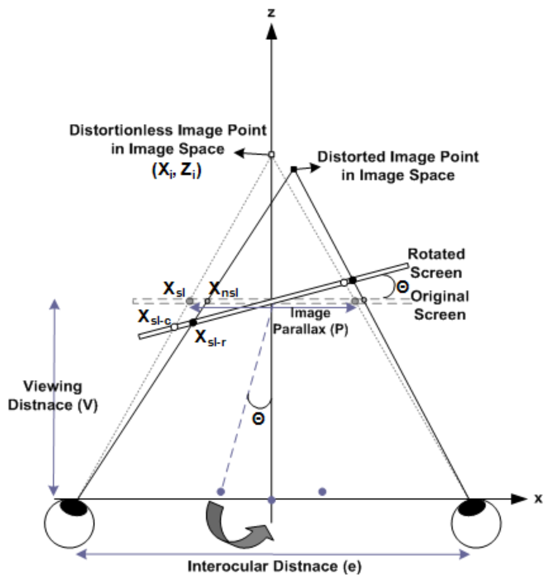
2. SIMULATION CONDITION

Figure 2 shows the geometrical model, which is used to simulation about distortion analysis of the stereoscopic image and its correction method in rotation movement of the observer. In order to easily calculate, we applied the same rotation angle in the screen instead of observer's rotation in the geometrical simulation model. In the figure 2, figure (a) shows case of observer's rotation and figure (b) shows case of screen's rotation. Generally, a stereoscopic image is calculated through relations between image parallax, which are distance between left and right image point on the screen, and interocular distance. Therefore, image distortions and correction results are expressed through relation between original screen and rotated screen in our simulation model. As a result, our geometrical simulation model is a method that expresses variation of the stereoscopic image through variation of the location of image points (left and right) on original screen in the figure 2. (b).

In the figure 2. (b), point 'X_{sl}' is the location of left image point on the screen when observer's viewing position is located in normal direction from center of the screen, and point 'X_{sl-r}' is the rotated position from point 'X_{sl}' when observer's viewing position is rotated θ degree from center of the screen. Here, point 'X_{sl-r}' expresses the distorted left image point. Point 'X_{sl-c}' is the corrected location of left image point on the screen for removal of the image distortion by point 'X_{sl-r}' in rotated observer's viewing position. Additionally, point 'X_{nsl}' which has the same observer's viewing position as point 'X_{sl}' is expressed in order to easily calculate the image distortion by point 'X_{sl-r}'.



(a) Case of observer's rotation



(b) Case of screen's rotation

Fig. 2 The geometrical model

3. SIMULATION RESULT

Figure 3 shows the simulation results about the image distortion and the corrected image through geometrical model of the figure 2. (b). In each graph of the figure 3, x axis is width and y axis is depth. The stereoscopic image condition used simulation in non-rotation condition of the observer is distortionless image condition with real scale (orthostereoscopic condition) through particular camera and display condition. At this time, used parameters in our simulation are as follows.

Table 1. Used parameters in our simulation

Parameter		value
Object space(Width * Depth)		1.6m * 3m
Camera Condition (Both camera)	Configuration	Parallel (CCD offset)
	interval	65mm
	Focal length	50mm
	Convergence Distance	536.22mm
	CCD size	36mm
Viewing condition	Interocular distance	65mm
	Display size	386.08mm(19inch)
	Viewing distance	536.22mm
	Rotation angle	10~ 30 degrees (left)

Figure 3. (a) shows object space used our simulation. Figure 3. (b) shows simulation result which is distortionless stereoscopic image with real scale, when observer's viewing position is located in normal direction from center of the screen. Figure 3. (c) ~ (e) show simulation result which is distorted stereoscopic image, when observer's viewing position is rotated 10, 20 and 30 degrees to the left from center of the screen. At this time, interval of width and depth is 10cm in all of the figures. In the figure (c) ~ (e), we can confirm the bending image space and different space ratio of right and left. And figure 3. (f) shows simulation result when the distorted image of figure 3. (d) is corrected. As a result, we could confirm that the simulation result of the figure 3. (f) expresses the same distortionless image space as simulation result of the figure 3. (b). But, a part of the space of the stereoscopic image doesn't display because the corrected image points on the screen move to outside of the screen. In order to complement this problem, we can use wide image, which is larger than screen width in distortionless real scale condition.

Figure 4 shows a degree of the image distortion according to the rotation angle of the figure 3. (c) ~ (e). Figure 4. (a) ~ (c) are comparison result of the image distortion according to depth and width direction in each depth. In the figure 4. (a) ~ (c), the tendency of distortion is different from each depth. But, we can know that the larger rotation angle of the observer is, the larger image distortion is in each depth. Through this result, we can know that the distortion of observer's rotation movement is complex, compared with forms of other observer's movement which are depth and horizontal direction. Also, we can show width distortion, which doesn't occurred by depth direction and horizontal movement of observer, through figure 4. (d) ~ (f). In the figure (d) ~ (f), width interval is nonlinear and the larger rotation angle of the observer is, the larger image distortion is in each depth. Also, we can show that the width image distortion of observer's rotation direction(- direction in the figure) is smaller than width image distortion of opposite direction(+ direction in the figure).

Therefore, large stereoscopic image distortion can be offered by observer's rotation movement, compared with depth and horizontal direction.

4. CONCLUSION

Image distortion is made by variation of observer's position in the stereoscopic display. Generally, an observer rotates his/her head toward the gaze direction. So, we must consider head rotation of the observer in practical horizontal movement of the observer. As a result, it is equal to rotation movement of the observer. We showed the stereoscopic image distortion which is made by this rotation movement and simulation result of its correction method. The corrected image has a loss of image in correction process, but we confirmed that the distortionless stereoscopic image can be offered to the observer through simulation result. At last, we confirmed the tendency of image distortion by rotation movement of the observer. Also, the larger rotation angle is, the larger distortion is in both directions which are width and depth.

In case of our result combined gaze tracking system, the correct stereoscopic image can be provided regardless of observer's position. And eye fatigue of observer can be relieved through providing correct stereoscopic image.

5. ACKNOWLEDGMENT

This work was supported IT R&D program of MKE/IITA.[2008-F-011-01]. "Development of Next-Generation DTV Core Technology"

6. REFERENCES

[1] A. Woods, T. Docherty, R. Koch, "Image Distortions in Stereoscopic Video Systems", Proc. Of SPIE, Stereoscopic Display and Virtual Reality Systems Ⅴ, vol.3295, pp.111-120 (1998).

[2] D. Diner, "A New Definition of Orthostereoscopic for 3-D Television", IEEE International Conference on Systems, Man and Cybernetics, pp.1053-1058 (1991).

[3] Haldun M. OZaktas, Levent Onural (Eds.), "Three-Dimensional Television", Spronger, pp. 474-477 (2008)

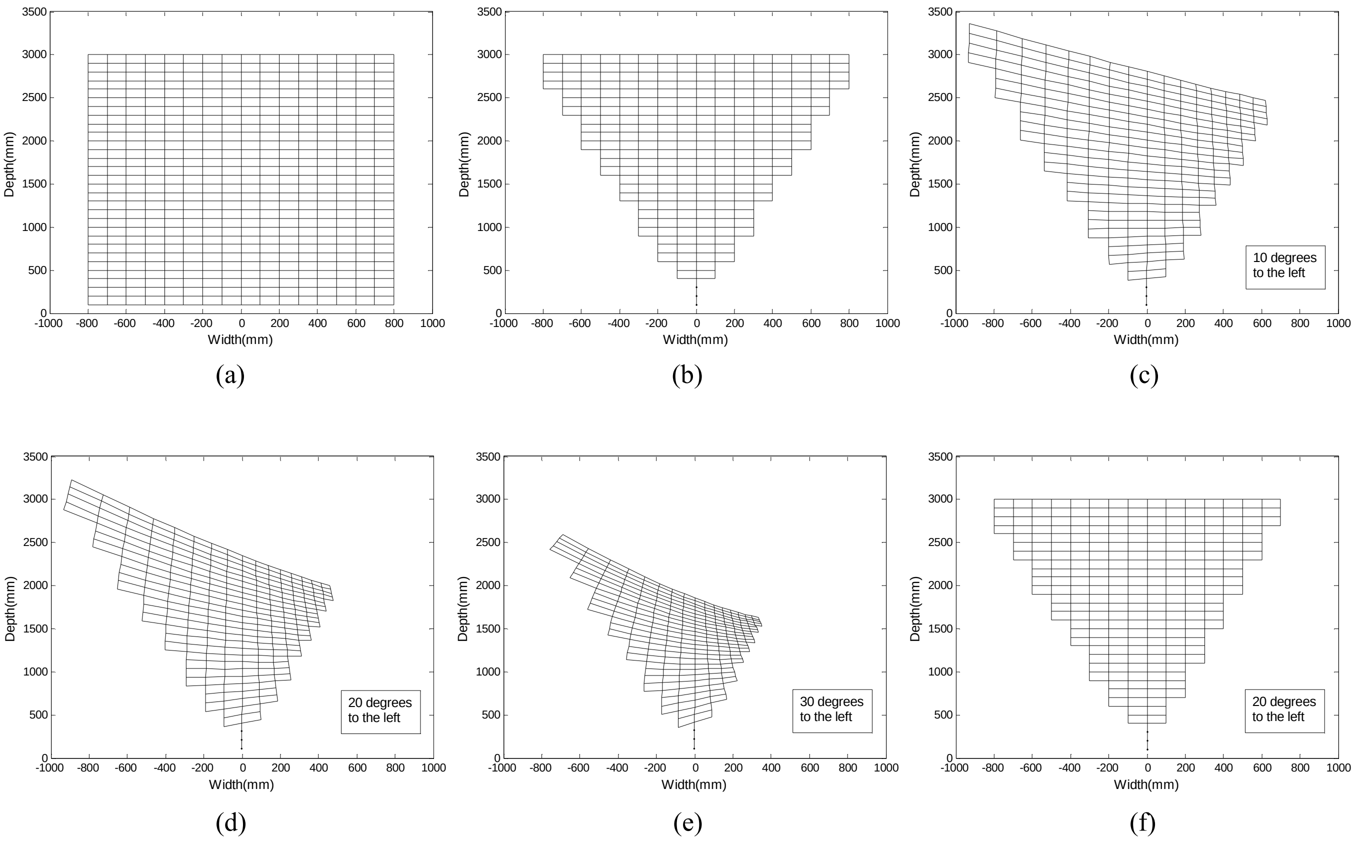


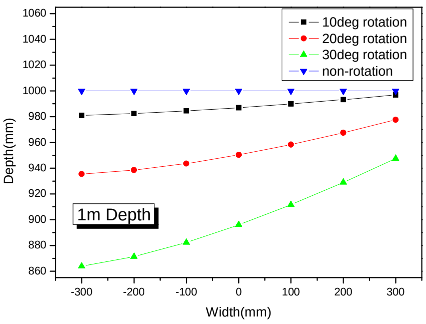
Fig. 3 The simulation results

(a) Object space

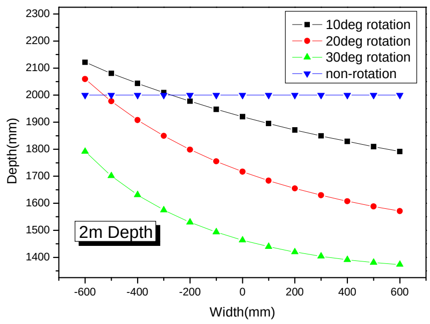
(b) Distortionless stereoscopic image with real scale when observer's viewing position is located in normal direction from center of the screen

(c) ~ (e) Distorted stereoscopic image when observer's viewing position is rotated 10, 20, and 30 degrees to the left from center of the screen

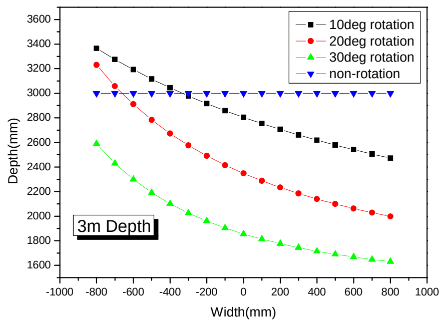
(f) Corrected stereoscopic image of figure (d)



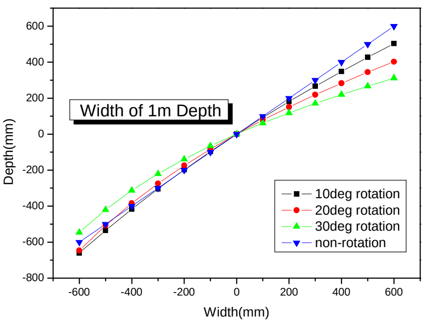
(a)



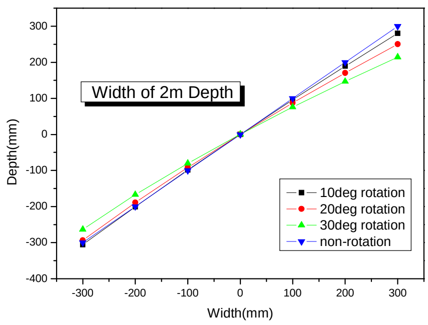
(b)



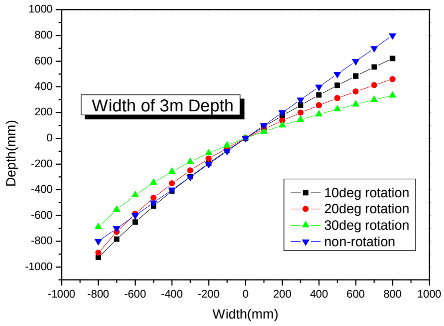
(c)



(d)



(e)



(f)

Figure 4. Degree of the image distortion according to the rotation angle of the figure 3. (c) ~ (e)
(a) ~ (c) Comparison result of the image distortion according to depth direction in each depth
(d) ~ (f) Comparison result of the image distortion according to width direction in each depth