A Viewer Centric Depth Adjustment For Stereoscopic Images

Chien Wu, Student Member, IEEE, Chung-Te Li, Chen-Han Chung, Cheng-Yuan Ko and Liang-Gee Chen*, Fellow, IEEE
DSP/IC Design Lab, Graduate Institute of Electronics Engineering
National Taiwan University, Taipei, Taiwan
Email: {mpemial,ztdjbdy,penal,kevin,lgchen}@video.ee.ntu.edu.tw

***Abstract*—In order to improve 3D viewing experience, we proposed stereoscopic image adjustment algorithm. We first adopted absolute disparity remapping for specific viewing distance, and then applied image resizing to deal with inconsistency of monocular cues and binocular cues. Compared with conventional image rendering, our proposed algorithm can reduce distortion of image by adjusting according to viewing conditions.**

I. Introduction

With the development of 3DTV technology, more and more applications of 3D retargeting are expected to spring up in the next generation of 3D display. The main purpose is applying adjustment technology to provide comfortable viewing experience. It is claimed by many people that after watching 3D videos for a long period of time, they suffer from headache and eye fatigue caused by 3D contents. Hence many researchers worked on depth adjustment to improve these artifacts [1]. Lang et al. [2] proposed non-linear disparity mapping operators to alter perceived scene depth, which is necessary for content adaption on different viewing geometries. In [3], a content-aware stereoscopic image display adaptation method was proposed. They considered the target resolution to resize the binocular image and adjust its depth into the comfort zone of the display. They also offered an important function to maintain the same depth during scene change to mitigate the effect of temporal depth discontinuities. We proposed a new method to adjust both object size and disparity map. Therefore, we can provide better viewing experience by minimizing the above mentioned distortion.

II. Literary Review

In this section, we briefly described some basic model in stereo vision, and some distortion generated by viewers movement and depth shifting algorithms is shown.

A. Depth And Size Perception

Relative size is the measure of the projected retinal size of objects or textures that is physically similar in size at different viewing distance [4]. Moreover the relative size cue is effective from 0.5m to 5000m [5]. If the object size is H, the retinal image size is R, and the focal length of human eyes is F, the viewing distance D can be given as $D{=}F{\times}H/R$.

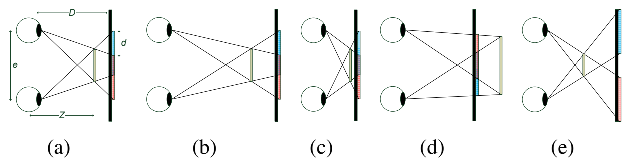

Fig. 1. Viewing geometry.

B. Depth And Size Distortion

As viewer moves backward from the screen, and the left and right views remain the same. In Fig. 1(b) shows that viewer may have the experience of increasing in depth perception. However, if the viewer moves forward to the screen, the ratio of baseline over screen size decreased; therefore, in Fig. 1(c) viewer may feel a decreased depth perception. Also, as Chang states in [6], if we apply only depth shifting method on stereo image, there will be size distortion due to the change of viewing condition. In Fig. 1(d), we showed that when decreasing the disparity of an object, viewer may feel magnification of the object. In Fig. 1(e) object became smaller than the original one.

III. Proposed Method

The proposed method considered viewing geometry and user information, and the overall system was depicted in Fig. 2 The inputs are color image and depth map. We use commercial depth sensor [7] to get users viewing distance, and then apply absolute depth remapping.

A. Depth Remapping

The concept of absolute disparity mapping is that we want to show the same perceived depth for the viewer at different viewing distance. Therefore, this approach is like ideal viewing condition in the geometry domain. We first use (1) to decide

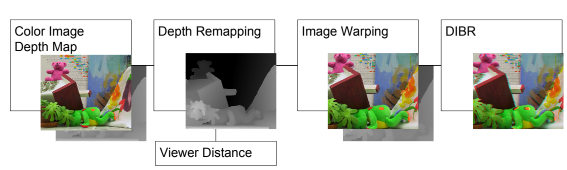

Fig. 2. Proposed system diagram

original perceived depth, and then apply (2) to shift disparity without changing perceived depth.

$$Z_i = \frac{e \times D}{e - d_i}, \tag{1}$$

$$d_o = e - \frac{e \times (D - \Delta D)}{Z_i - \Delta D}, \tag{2}$$

where Z_i is original perceived depth. D is the viewing distance and e is interocular distance which is usually set to 6.5cm. d_i is the initial image disparity. After the viewer moves forward or backward to the display, we can get the new perceived depth Z_o. As the result, the proposed method can reduce the depth distortion and keep the same stereo perception under different viewing condition.

B. Color Image Domain Warping

Traditional system seldom takes image warping into account, so it may cause size distortion while applying depth shifting. To deal with this artifact, we proposed image resizing algorithm to reconstruct the original scale. We used geometry assumption to get the scaling ratio. When people move close to the objects, we feel the nearer the object, the bigger it grows in the real world viewing experience. Besides, for the scene far from the viewer, it almost remains the same size. Using the geometry relation we can solve the resizing ratio for each object. The scaling ratio is decided by equation as following

$$ratio = \frac{Z_i}{D} \times \frac{D + \Delta D}{Z_o}, \tag{3}$$

$$x_o = x_i \times ratio + \frac{width}{2}, \tag{4}$$

Our method first calculated the original horizontal position x_i and then calculated the virtual position x_o according to the viewers movement. Then color image and depth map are combined to render two/multi views image by using depth image-based rendering (DIBR).

IV. Experiment Result

Fig. 3 shows the result of our algorithm. Fig. 3(a) shows our proposed synthesis image which convergence distance is 2.1m, and Fig. 3(b) are results synthesis at 1.8m. Fig. 3(c) are synthesis at 1.6m. Table 1 shows the percentage of occlusion points and the peak signal-to-noise ratio(PSNR). The PSNR is defined by comparing our result and original image with ground truth that was taken by [7]. At synthesis at 1.6m, there is approximately 5% occlusion in the image. Consequently, it is too difficult to apply hole-filling and it may decrease the quality of stereo image. Our works are at average 5.26dB higher than original stereo images, therefore can provide better viewing experience in a restricted viewing distance.

TABLE I
EXPERIMENTAL RESULTS

Simulation Distance(m)	2.1	2.0	1.8	1.6
Occlusion Regions(%)	6.0	0.0	1.2	5.1
Proposed PSNR(dB)	19.2	∞	21.5	18.2
Original PSNR(dB)	15.4	∞	14.9	12.8

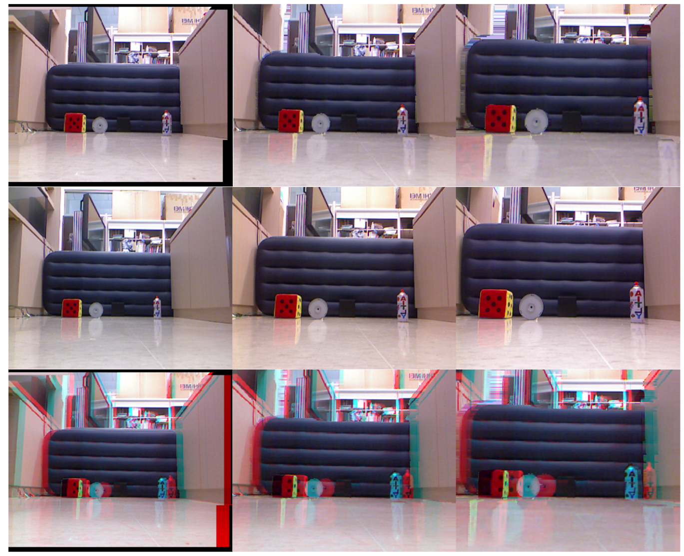
(a) (b) (c)

Fig. 3. Experiment result. First row: synthesis image, second row are ground truth at different viewing distance, and the last row are red-cyan images of proposed method. (a) is viewing distance synthesis at 2.1m, (b) is at 1.6m and (c) is at 1.8m.

V. Conclusion

In this paper we provided the depth adaptation to reduce depth and image size distortion. We apply viewing geometry to our algorithm which uses a sensor to get viewers's conditions. The quality of remapping and warping method is evaluated by ground truths which were taken under different distance.

References

[1] F. Devernay and S. Duchene. New view synthesis for stereo cinema by hybrid disparity remapping. In International Conference on Image Processing (ICIP), Hong Kong, 2010.
[2] M. Lang, A. Hornung, O. Wang, S. Poulakos, A. Smolic, and M. Gross, "Nonlinear disparity mapping for stereoscopic 3D," in ACM Trans. Graph. (SIGGRAPH), 2010, vol. 29, pp. 75:1V75:10.
[3] Che-Han Chang; Chia-Kai Liang; Yung-Yu Chuang; , "Content-Aware Display Adaptation and Interactive Editing for Stereoscopic Images," Multimedia, IEEE Transactions on , vol.13, no.4, pp.589-601, Aug. 2011
[4] De Silva, V.; Fernando, A.; Worrall, S.; Arachchi, H.K.; Kondoz, A.; , "Sensitivity Analysis of the Human Visual System for Depth Cues in Stereoscopic 3-D Displays," Multimedia, IEEE Transactions on , vol.13, no.3, pp.498-506, June 2011
[5] J. Cutting and P. Vishton, Perceiving layout and knowing distances: The interaction, relative potency, and contextual use of different information about depth, in Perception of Space and Motion, W. Epstein and S. Rogers, Eds. New York: Academic, 1995, pp. 69V117.
[6] Chang Yuan, Hao Pan, Scott Daly, "Stereoscopic 3D Content Depth Tuning Guided by Human Visual Models," in the Proc. of SID Symposium, 05/2011
[7] Microsoft, Microsoft for Kinect [Online]. Available at: http://www.microsoft.com/en-us/kinectforwindows/