ATLANTIS PRESS
Advances in Computer Science Research, volume 87
3rd International Conference on Mechatronics Engineering and Information Technology (ICMEIT 2019)

Contrast Experiment and Theoretical Analysis on Three-dimensional Display of Multi-view Parallax Barrier

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Abstract. Contract experiment on three-dimensional display of one-dimensional parallax barrier in different viewpoints is conducted, influence of system parameters on resolution and viewing freedom are studied, and theoretical analysis is made simultaneously. On this basis, three-dimensional display experiment of multi-view two-dimensional parallax barrier is conducted.

Keywords: Multi-view; parallax barrier; three-dimensional display.

1. Introduction

Three-dimensional display technology has become a very remarkable frontier technology since 21st century and naked-eye three-dimensional display has especially become the emphasis of study[1-2]. Three-dimensional display technology of parallax barrier for cylindrical lens is one of the most mainstream three-dimensional naked-eye display technologies at present. It has high resolution ratio and large field angle, and it's able to realize the advantages of high brightness display, mature manufacturing technology and abundant three-dimensional image sources [3-6]. This text conducts a contrast experiment on three-dimensional display of multi-view two-dimensional parallax barrier and verifies the influence of system parameters on image resolution and viewing freedom through the experiment. All these are of great reference significance to design of three-dimensional display system for two-dimensional parallax barrier. In the meantime, the experiment verifies that three-dimensional display system for two-dimensional parallax barrier can provide both horizontal binocular parallax and longitudinal monocular motion parallax.

2. Implementation and Result Analysis on Three-Dimensional Display Experiment of Multi-View One-Dimensional Parallax Barrier

According to the relation between barrier line number and three-dimensional effect, we choose 25-line barrier with the strongest three-dimensional intensity as the tool of our experiment. We choose 3dsMAX software based virtual stereo camera shooting as the means of obtaining parallax image[7]. When parallax image is shot, image parameters shall be determined at first, barrier period is set as p, barrier inclination angle is set as θ, subpixel width of two-dimensional display screen is set as Wp, and number of viewpoints adopted is set as K, and these 4 parameters shall be properly matched and meet the following relation when they are chosen [7-9].

$$\mathrm{K} = \frac{p}{Wp\cos\theta} = ceil(\frac{p}{Wp})$$

In the formula, ceil () represents round up to an integer. We set up a target camera at the optimal shooting distance of 5m with a 25-line barrier, place the target camera in the coordinates (0, 0, 50cm), place shooting point in the coordinates (500cm, 0, 50cm), build Model A in the shooting point (500cm, 0, 0), adopt dynamic shooting method, and take human eye PD 6cm as the shooting distance. Parallactic angle is about 6/500=0.012°∈(-0.2°, 0.2°) at the moment and it meets the requirements.

When the camera moves to record the process, x and z coordinates remain unchanged, y coordinate changes every other 6cm from -21cm and -27cm to -21cm and -27cm to get 8 frames and 10 frames successively. The corresponding parallax images can be obtained by rendering the camera, shown in figure 1. and figure 2.

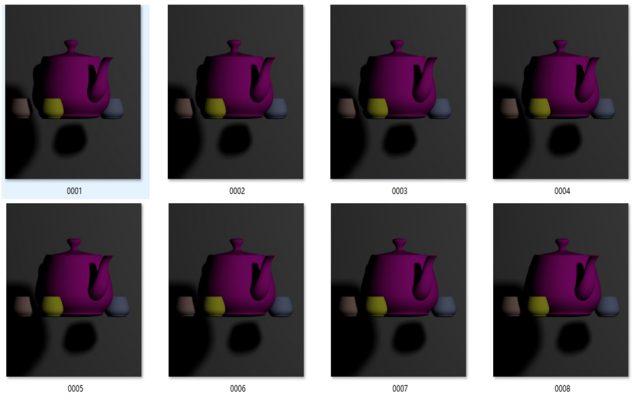

Figure 1. 8-view one-dimensional parallax image set

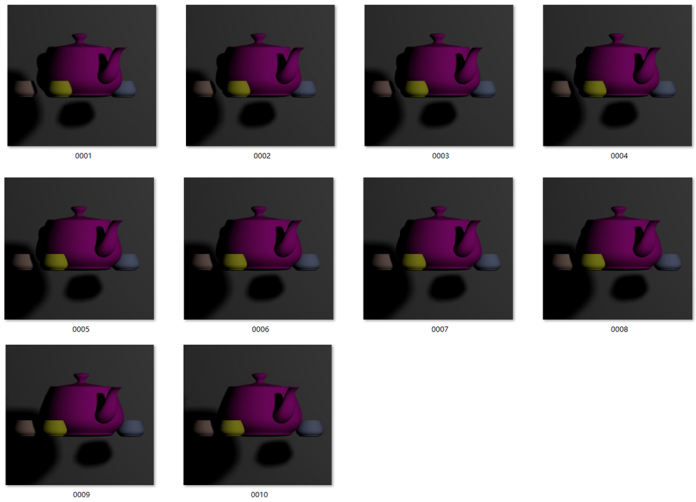

Figure 2. 10-view one-dimensional parallax image set

We use Matlab to obtain the synthetic program of 8-view and 10-view one-dimensional parallax composite graphs. After program run, composite graphs whose sizes are adjusted by Photoshop are shown in figure 3[10-11].

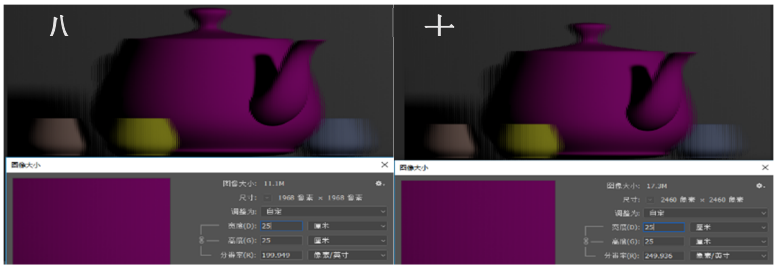

Figure 3. 8-view and 10-view one-dimensional parallax composite graphs

Subpixel width matched with 8-view 25-line parallax barrier is 0.127mm so corresponding resolution ratio per inch shall be 25.4/0.127=200 px/inch and it's very approximate to the resolution ratio 199.949 px/inch shown in the figure. In the same way, subpixel width matched with 10-view 25-line parallax barrier is 0.1016mm so corresponding resolution ratio per inch 25.4/0.1016=250 px/inch and it's very approximate to the resolution ratio 249.936 px/inch shown in the figure. And these resolution ratios are all less than the maximum resolution ratio of printer. Thus, one-dimensional

parallax barrier composite graph that we need is obtained. After printing one-dimensional parallax composite graph, the position between graph and parallax barrier of cylindrical lens is adjusted so as to reach better three-dimensional viewing effect and 10-view viewing effect is found to be the best. The reason is that when viewport width is set as interpupillary distance, for 8-view parallax barrier, left and right eyes observe 1-2, 2-3, 3-4, 4-5, 5-6, 6-7 and 7-8 width parallax images successively when the observer moves from left to right and correct stereo image is generated through brain fusion. If keep moving, the observer will see 8-1 width parallax image and pseudo-stereo image is generated through brain fusion. Thus it can be seen that for 8-view, when viewport width is set as interpupillary distance, the observer has only 1/8 chance to see pseudo-stereo image in case of horizontal move in the optimal viewing distance. In the same way, for 10-view, the observer has only 1/10 chance to see pseudo-stereo image under the same condition. This shows that 10-view viewing effect is the best.

3. Implementation and Analysis on Three-Dimensional Display Experiment of Two-Dimensional Parallax Barrier

Taking shooting parameters of 10-view one-dimensional parallax barrier camera as the basis, we add time-variable displacement in vertical direction to the camera and initial position of the camera is (0, 27cm, 23cm). Afterwards, each time when the camera changes a frame, x and z coordinates remain unchanged while y coordinate is deducted by 6cm until the tenth frame, and coordinates of the camera are (0, -27cm, 23cm). In the eleventh frame, x coordinate of the camera remains unchanged, y coordinate is refreshed and made equal to 27cm, and z coordinate is added by 6cm on the original basis to obtain the eleventh frame simultaneously, and the coordinates of the camera are (0, 27cm, 29cm) at this time. Afterwards, each time when the camera changes a frame, x and z coordinates remain unchanged while y coordinate is deducted by 6cm until the twentieth frame. In the twenty-first frame, x coordinate of the camera remains unchanged, y coordinate is refreshed and made equal to 27cm, and z coordinate is added by 6cm on the basis of the previous frame. This law is followed until 100th frame and the final position of the camera is (0, -27cm, 77cm). After camera rendering, 100 parallax graphs can be obtained and they are divided into 10 sets. Each set of parallax graphs are all 10-view one-dimensional parallax sequence charts, they are synthesized through 10-view one-dimensional parallax graph synthesizing program, and sizes are adjusted by Photoshop to obtain 10 sets of 10-view one-dimensional parallax composite graphs and these ten graphs form a set of one-dimensional parallax sequence charts shown in figure 3. Nothing but the parallax only changes in the vertical direction. We can extract the pixel through Matlab, synthesize these 10 graphs, and use Photoshop to adjust the sizes to obtain desired two-dimensional parallax barrier composite graph shown in figure 4.

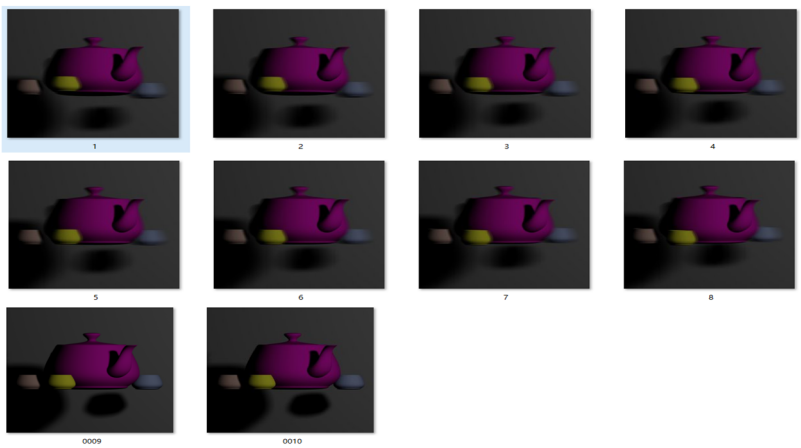

Figure 4. 10 sets of 10-view one-dimensional parallax composite graphs

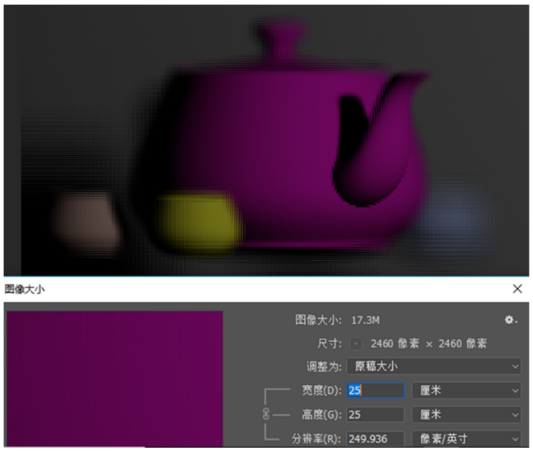

Figure 5. 10-view two-dimensional parallax barrier composite graph

It can be found that two-dimensional parallax image is much more blurred than one-dimensional parallax image and the resolution ratio declines sharply. In exchange for that, when human eyes move up down relative to the image, the image rotates and monocular motion parallax in the vertical direction comes into being.

4. Conclusion

This text conducts contrast experiment on three-dimensional display of multi-view two-dimensional parallax barrier on basis of theoretical analysis to find that along with the increase of viewpoint number, parallax image resolution is higher and viewing freedom is larger, which is of great reference significance to the design of three-dimensional display system for two-dimensional parallax barrier. In the meantime, simulation experiment verifies that three-dimensional display system for two-dimensional parallax barrier can provide both horizontal binocular parallax and longitudinal monocular motion parallax, which is of great application prospect to the fields such as three-dimensional sand table and three-dimensional panel display.

Acknowledgments

This work was financially supported by Scientific Research Fund of Yunnan Open University.

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