Development of One-Dimensional Integral Photography

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Keywords: one-dimensional integral photography, multi-view stereoscopic image, depth perception

ABSTRACT

A prototype that can produce one-dimensional integral photography, which can display only the parallax in the horizontal direction, was developed using a 4kLCD panel and a lenticular lens. In addition, not only the object placed in the computer was able to be displayed by one-dimensional integral photography, but the real object was also captured and displayed. Furthermore, evaluation of the depth perception and measurement of the accommodation response were carried out using the prototype one-dimensional integral photography.

INTRODUCTION

In conventional stereoscopic images, there is the possibility of visual fatigue and spatial distortion in reproduced stereoscopic images. On the other hand, one dimensional integral photography (Hereinafter abbreviated as 1DIP), which only displays horizontal parallax, is said to be able to display three dimensional images similar to real objects without visual fatigue. In this article, 1DIP was generated using CG. 1DIP was also generated by real camera, and the evaluation of the depth perception and measurement were of accommodation response carried out using the prototype 1DIP.

1 Generation Method

In the generation of 1DIP, image pickup of a multi-view stereoscopic image was performed using a horizontal camera array using the fixation point shown in Fig. 1. The number N of multi-view stereoscopic images used is given by the following equation.

$$N = \frac{r}{d} \qquad (1)$$

Where r is the lens pitch of the lenticular lens and d is the pixel pitch of the display

Next, pixel position conversion shown in Fig. 2 was performed to generate an elemental image. Assuming that the image generated is P(i,j) and the position of the multi-view stereoscopic image is X (in, jn), the pixel position conversion is expressed by the following equation:

$$P(i, j) = X(i_n' \times N - (N - n), j_n') \qquad (2)$$

The generated image was displayed on the LCD, and the three-dimensional image was displayed by attaching the lenticular lens. Table1 shows the specification of the prototype one-dimensional integral photography. Since the relationship between the lenticular lens and the pixel pitch is not an integer ratio, interpolation or deletion processing is required for the pixels in the element of image. For prototype 1DIP there is not an integer ratio, interpolation processing was performed. In the interpolation process, the interpolation uses the average values from the neighboring pixels.

1.1 Generation from real camera images

The above method was applied to a Nikon D 800 E camera to generate 1DIP. In order to realize a horizontal camera array, a multi-view stereoscopic image was generated by moving the camera, which was pointed to the fixation point, in the horizontal direction, and picking-up images by dividing them several times. The resolution of generated multi-view stereoscope was processed, pixel position conversion was performed, and the elemental image was generated. The photograph is shown in Fig. 3, and the display image is shown in Fig. 4.

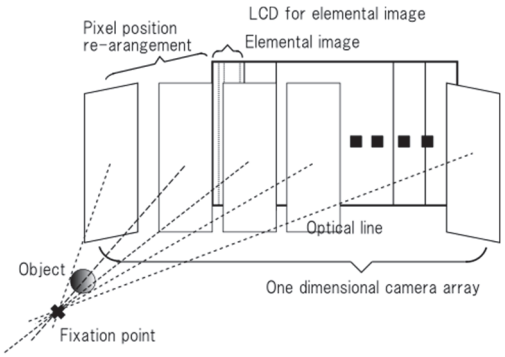

Figure 1 Method of Multi-ocular Stereoscopic Image Imaging

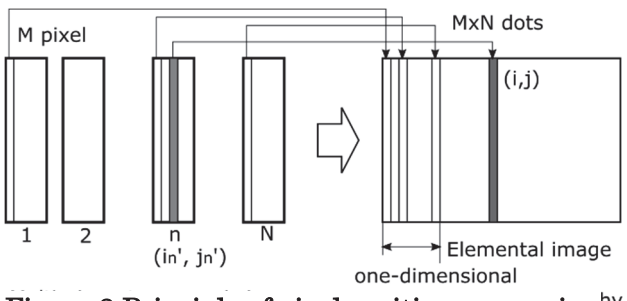

Figure 2 Principle of pixel position conversion[hy]

Table 1 Main specifications

LCD	
Num. of dot	4K LCD 3840(H)x2160(V) (SONY SO-03H)
Size	5.5inch
Dot pitch	31.51 μm
Lenticular sheet	
Lens Dia.	400μm
FL	2.2mm
Image	
Resolution	320(H)x2160(V)
Elemental im.	12(H)x2160(V)

Figure 3 Scene using a real camera

Figure 4 Photograph of one-dimensional integral photography

2 Depth perception distance

2.1 Experimental method

Maltese Cross was used as a visual target for the subjective evaluation test of depth perception for evaluation of depth perception. The viewing distance was 60 cm. The depth position of the visual target was defined as the distance from the display 18 cm in the far range and 15 cm in the near range, and the change of the depth distance was defined as 3 cm. The scale method was used for subjective perception and evaluation of depth distance position. Three subjects participated.

2.2 subjection evaluation result

Figure 5 shows the experimental results. It is understood from this figure that subjects tend to perceive the depth of the target linearly in a depth range from 15 cm to 18 cm. Therefore,these experimental results suggest that there is not much distortion in the image in the depth direction in the prototype1DIP. However, the perceived depth was about 1/2 of the calculated value.

3 measurement of accommodation response

3.1 Experimental method

Maltese Cross was used as a visual target. The viewing distance to the display was 50 cm. The visual target was displayed at a range of 18 cm to 15 cm from the display, and the change in the depth distance was set to 3 cm. For measurement equipment, WAM -5500 (made of gear) was used. Two subjects were included.

3.2 Experimental Results

Figure 6 shows the experimental results. The experimental results show that the accommodation response tends to change linearly. This linear change is also observed the depth of focus. that there is no conflict of convergence and accommodation unlike the conventional stereoscopic image based on binocular fusion. That is to say, the prototype 1DIP seems to be able to reproduce the real space, and it is possible to often see a three-dimensional image.

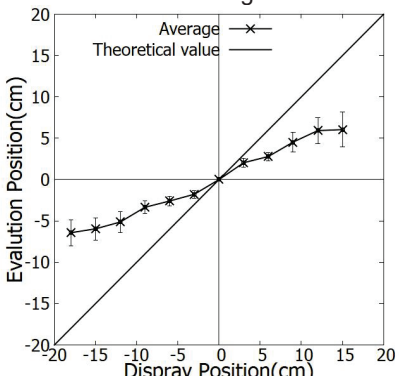

Figure 5 experimental result

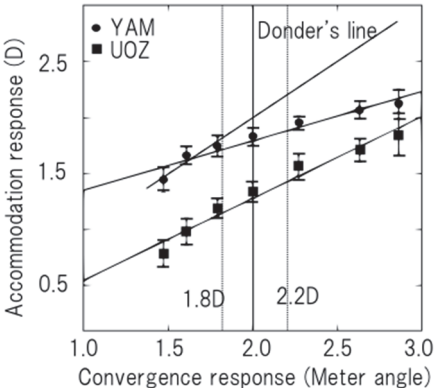

Figure 6 experimental result

4 CONCLUSIONS

In this article, the capturing object in the computer and picking-up object in the real space in 1DIP were described, Also, the evaluation on depth perception and accommodation response of the prototype equipment was investigated. From these results, 1DIP can be expected to be an effective method for generating three-dimensional images which appear the same as real space.