3D Aerial Display with Micro Mirror Array Plate and Reversed Depth Integral Photography

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Figure 1: left: 3D aerial display of swimming fish. right: 3D aerial display of diamonds

ABSTRACT

We propose a new aerial imaging display in which autostereoscopic objects with horizontal and vertical parallax appear as if they are floating in the air. This system operates by displaying an integral photography image in which depth is reversed beforehand and by observing the image from the other side of a micro mirror array.

CCS CONCEPTS

• **Applied computing → Education**; **Interactive learning environments**;

KEYWORDS

Aerial display, Integral photography, Micro mirror array plate

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1 INTRODUCTION

When a micro mirror array plate (MMAP) is used, a screen such as a liquid crystal display (LCD) can be displayed as if it is floating in the air. However, given that an image on LCD is usually 2D rather than 3D, the image floating in the air also appears as a planar 2D image. An aerial display that combines a volumetric display and an MMAP using a rotating screen has been proposed to display an image with depth in the air [Hunter et al. 2017], but this system requires sophisticated and costly mechanical devices. Meanwhile, a unique system for displaying an aerial image by applying the principle of reversibility of light-path to a light field camera [Fujii et al. 2018] has been proposed. However, in principle, only the images taken with the light field camera can be displayed. Therefore, we propose a new aerial display system that projects 3D images of integral photography (IP) into the air by MMAP (Figure 1). This system does not require stereo glasses and has parallax not only in the horizontal direction but also in the vertical direction. The system consists of an IP display and an MMAP. Therefore, installation and maintenance of the system are easy because no mechanical moving parts are required. Furthermore, our system can display anything that can be displayed by IP, such as live action or computer graphics (CG). Accordingly, imaginary objects that cannot be expressed with real objects can be displayed in 3D in the air, thereby greatly expanding the application possibilities.

2 METHOD

The proposed system consists of an IP that displays an omnidirectional parallax 3D image by using an LCD and a fly's eye lens and an MMAP for displaying the image in the air (Figure 2). Notably, the MMAP reverses the depth. Consequently, an image with the reversed depth will be displayed if this is left as it is, as shown in Figure 2(a). If two MMAPs are used, then the depth-inverted image can be inverted and restored, but the image becomes dark and the apparatus becomes large and costly with this method. Figure 2(b) shows a potential solution of reversing the depth of the 3D image displayed on the IP display in advance and returning to the correct depth by passing the MMAP. When the extended fractional view method [Yanaka 2008] is used to synthesize an IP image, the depth can be reversed by slightly changing the synthesizing method. Figure 3 shows a flowchart of multi-view rendering of a 3DCG scene that comprises fish and aquatic plants with an $8 \times 8 = 64$ virtual cameras, followed by synthesis and display of the IP image. In ordinary IP, the horizontal camera position number is u and the vertical camera position number is v in the multi-viewpoint image (Figure 3). When the depth is reversed, u' and v' should be used instead of u and v, respectively.

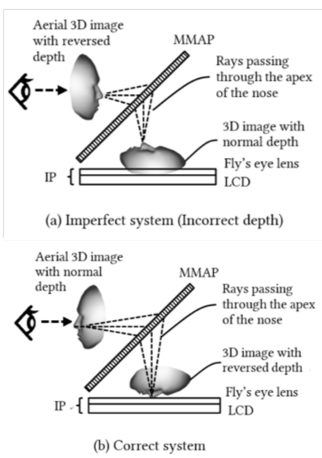

Figure 2: Reversal of the depth caused by MMMP.

3 EXPERIMENT

In the experiment, ASKA3D [Ltd. 2018] was used as the MMAP. An animation sequence of fish swimming around was created, as shown in Figure 1, to confirm that the depth was correctly reproduced. The modeling of the objects (i.e., fish, seaweed, and rock) was conducted in Maya. The models were exported in fbx format and imported into Unity. The fish were programmed to be circulated using C script of Unity, IP images were synthesized with the shader of Unity, and exported as png images of consecutive number; ultimately, a movie sequence was created. We also experimented with IP still images of diamonds with easily detectable 3D effects as shown in Figure 1. In both cases, the correct depth was reproduced as the 3D aerial image.

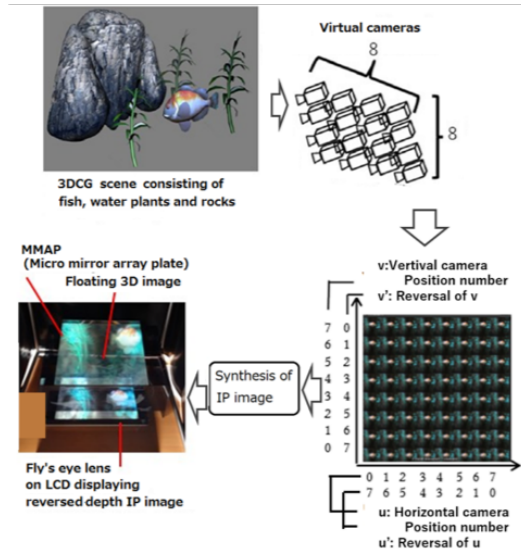

Figure 3: Diagram of the proposed system.

4 CONCLUSION

We proposed a new 3D aerial display that displays an image with reversed depth. This system operates by reversing the parallax in the vertical and horizontal directions when creating an IP image from a 3DCG model and inverting the depth with MMAP to return to the correct depth. When we created and displayed an animation of fish orbiting with this method, we found that the correct depth was reproduced. The combination of IP and MMAP will introduce new possibilities for expression, such as media arts and digital signages.

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