Creation of 3DCG Animation Using a Four-Plane Depth-Fused Display

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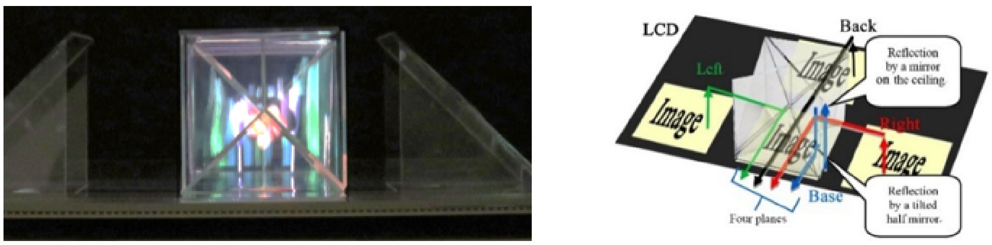

Figure 1: (left) Four-plane depth-fused 3D display. (right) Four-plane DFD system with cubic half mirrors.

ABSTRACT

A four-plane depth-fused display (DFD) is an autostereoscopic system that can display four images at different depth positions using a single liquid crystal display and mirrors or half mirrors. This system increases the number of images in the depth direction, thereby enhancing stereoscopic effect. To date, however, the contents of proposed DFD remain limited to still images. Therefore, we introduced an animation that included object motion in the XYZ space in four planes into DFD. This approach considerably increased the sense of depth.

CCS CONCEPTS

• **Computing methodologies** → **Graphics systems and interfaces**; **Perception**;

KEYWORDS

Depth-fused display, 3D display

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1 INTRODUCTION

Among various autostereoscopic display methods, the depth-fused display (DFD) system [Suyama et al. 2004] presents a 3D image by changing its luminance ratio on two displays with different depth positions. DFD does not use a lens array. Thus, this method has the advantage of displaying high-resolution images. Another advantage of DFD is its capability to display a stereoscopic image using a simple apparatus. DFD production only requires liquid crystal display (LCD) and a half mirror. However, when three or more transparent LCDs are layered, the apparatus becomes complicated and costly. Gocho et al. [2016] solved this problem by proposing a four-plane DFD system that can display four images at four different depth positions using a single LCD, mirrors, and half mirrors. To date, however, the contents of a four-plane DFD remain limited to still images in the systems of both Suyama et al. and Gocho et al. Viewers are expected to perceive an enhanced stereoscopic effect by introducing an animation with an object that moves in the depth direction. To address this gap, we constructed a new display method with animation.

2 METHOD

2.1 Hardware Setup

Figure 1 shows the configuration of the proposed system. Three of the four different images displayed on the LCD of a PC are reflected by mirrors set at an angle of 45° to the LCD. These mirrors are arranged into a cubic half mirror system. The remaining image, which is displayed directly under the cubic half mirror system, passes through this system once and is reflected by a plane mirror on its upper surface and then by a tilted half mirror. The cubic half mirror system is an optical component composed of a combination

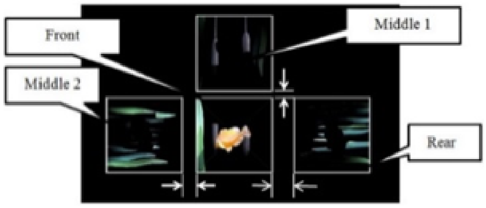

Figure 2: Four images that will be displayed on the LCD.

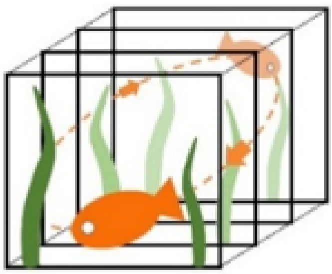

Figure 3: Path of the goldfish swimming in XYZ space in the four planes.

of three half mirrors. This system integrates four images that enter from four different directions into a set of images and displays these images at different depth positions when viewed from the front.

2.2 Image for Display

Figure 2 shows an example of four images that will be displayed on an LCD. Each image corresponds to one of the four layers of images, namely, front, middle 1, middle 2, and back. This setup facilitates the display of stereoscopic images with depth information on a single LCD.

3 CREATION OF ANIMATION WITH DEPTH MOVEMENT

3.1 Creation of Animation

An animation of a goldfish moving in XYZ space was created. In the image, black will appear transparent when displayed on the four-plane DFD. Thus, black was used as the background of the scene. This approach created a sense of space in the cube. In addition, seaweeds were placed at various depth positions to achieve contrast effect, wherein the goldfish passes between seaweeds. The animation of the goldfish swimming around in circles contains 80 frames (24 frames per second) and can be looped and replayed. Figure 3 shows a path of the goldfish swimming in XYZ space in the four planes. The goldfish stops for a while when it reaches the front layer so that the user could easily observe the goldfish.

3.2 Creation of Depth-Fused Images

Each image in the animation was rendered frame by frame. Depth maps were generated simultaneously for each frame with the rendered images. Figure 4 provides an example. The process after this procedure is the same as the method presented by Gocho et al.

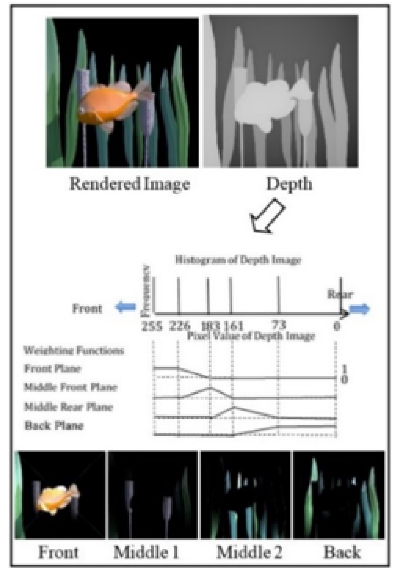

Figure 4: Production of images for the four-plane DFD.

[2016]. However, we introduced a new algorithm so that effective pixels, which are pixels that do not belong to the transparent (black) region, are approximately evenly distributed among all planes.

4 EXPERIMENT

The PC used for the experiment is a Microsoft Surface Book with a 13.5 inches LCD with a resolution of 3000 by 2000 pixels. Transparent acrylic plates were used as a half mirror because high transmittance was required. A strong sense of depth was achieved because the fish moved across multiple layers

5 CONCLUSIONS

We introduced animation with movement in XYZ space into a four-plane DFD system. This approach considerably increased the sense of depth. Our system is inexpensive. Content production is easy because 3DCG animation contains depth information and can be outputted as a rendered image with a depth map. The distribution of pixels among the four layers in the depth direction can be freely adjusted when only one image with depth map information is rendered. Unlike conventional stereoscopic images, re-rendering from 3DCG software is unnecessary each time depth is adjusted. The proposed system will be applied to various areas, including interactive media, such as mobile games, electronic books, and digital signage systems.

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