Mid-air Plus: A 2.5 D Cross-sectional Mid-air Display with Transparency Control

Hiroki Yamamoto*[1], Hajime Kajita[1], Hanyuool Kim[1], Naoya Koizumi[1], and Takeshi Naemura[1]

[1]The University of Tokyo

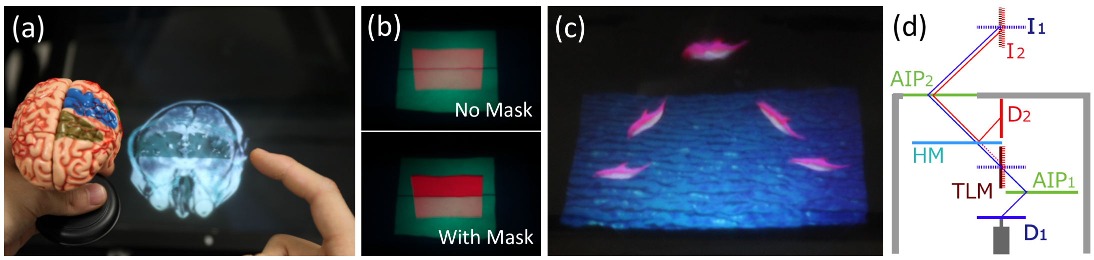

Figure 1: *(a) Interaction with Mid-air Plus, (b) Visibility Control with Optical Mask, (c) Application (Entertainment), (d) Optical Configuration*

1 Introduction

In design process and medical visualization, e.g. CT/MRI cross-sectional images, exterior and interior images can help users to understand the overall shape of volumetric objects. For this purpose, displays need to provide both vertical and horizontal images at the same time. To display cross-sectional images, an LCD display [Cassinelli et al. 2009] and image projection [Nagakura et al. 2006] have been proposed. Although these displays could show internal images of volumetric objects, seamless crossing of internal and external images cannot be realized since the images are limited to physical displays.

In this paper, we propose a novel display concept, Mid-air Plus, that can display both vertical and horizontal images that cross each other. To overcome the limitations of physical displays, we provide visual images with mid-air images formed by imaging optics. Moreover, we realize visibility control between mid-air images with an optical mask by using a transparent LCD. Occlusion between mid-air images can be achieved with this mask. Thus, users can see mid-air images more clearly with occlusion.

2 Experience

Through Mid-air Plus, we intend for users to be able to see images of the internal structure of objects while they freely manipulate physical models .The current 3D display is not able to display a sufficient depth in a short distance due to the fusion limit of human vision. However, Mid-air Plus focuses on cross-sectional viewing. It enables the user to see a cross-sectional image of the same size as the the model in their hand. With Mid-air Plus, users can see two layers of mid-air images in the horizontal and vertical directions. These two image layers can provide both overall and internal images at the same time. Moreover, users can move the horizontal image layer to different heights in applications. This helps users to see and understand the internal structure of volumetric objects. Since a mid-air image has no physical shape, users can freely access the images and even place physical objects around them. The usage of physical objects will enable more intuitive user interaction.

With these merits of Mid-air Plus, we propose interactive applications that include visualizations for architecture design and medical science. As shown in Fig.1 (a), the overall shape and cross-sectional image of a brain can be displayed at the same time. Users can also discuss a building design while viewing external and internal images and looking at the images of the design shown from Mid-air Plus. Moreover, we can realize entertaining visual expressions by using the combination of horizontal and vertical image layers. In Fig.1 (c), for example, a dolphin can jump from and dive into sea water. Thus, we believe our proposed system can broaden the visual expressions in both workspaces and playgrounds.

3 Principle

The design of Mid-air Plus consists of two main functions: crossing two layers of mid-air images in the horizontal and vertical directions and forming an optical mask for a vertical image. Figure 1 (d) illustrates the system configuration of Mid-air Plus. As light sources for mid-air images, we used two displays (D1, D2). To form mid-air images, we placed two AI-Plates (AIP1, AIP2). This AI-plate is a plate-shaped imaging optic that can form a mid- air image at the plane-symmetric position by reflecting the incident lights from D1 and D2. To cross the mid-air images, we used a half-silvered mirror (HSM). For an optical mask between mid-air images, we placed a transparent LCD monitor (TLM) at the position where the mid-air images are crossed.

Our main contribution of this research is a optical mask technique for mid-air images. By displaying a black image from the TLM, we realized occlusion expression [Fig.1 (b)]. The images include two crossed image layers, one for the horizontal direction (I1) and the other for the vertical plane (I2).

*e-mail:mid-air@nae-lab.org

SIGGRAPH 2015 Posters, August 09 – 13, 2015, Los Angeles, CA.
ACM 978-1-4503-3632-1/15/08.
http://dx.doi.org/10.1145/2787626.2792605

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