Omnidirectional display that presents information to the ambient environment with optical transparency

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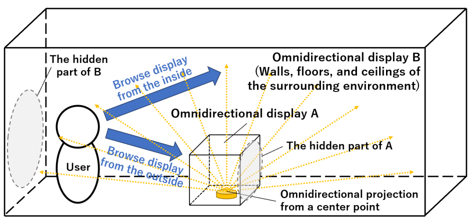

Figure 1: Two omnidirectional display A and B

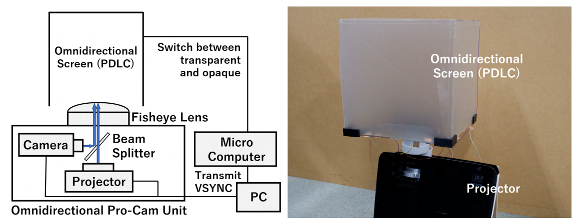

Figure 2: The proposed system

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1 INTRODUCTION

Projection mapping is an information presentation method (called omnidirectional display) in which images are projected on the entire surface (all sides) of a three-dimensional structure (screen). Using this method, users can browse the projected images on the three-dimensional shape from various angles.

Omnidirectional display has the advantage that multiple people can simultaneously browse the highly immersive images projected onto a real three-dimensional shape in front of them without the need for HMDs or similar devices. In addition, displays of various shapes, from simple box/sphere shapes to complex three-dimensional shapes, can be realized.

In this study, we categorize omnidirectional displays into two different types depending on whether the user browses the three-dimensional shape on which the images are projected "from the outside" or "from the inside" (Fig.1).

The former (A in Fig.1) can be directly held in the hand and browsed from various angles if it is small[Pla and Maes 2013], or surrounded by several users simultaneously if it is medium-sized [Beyer et al. 2011]. The latter (B in Fig.1) enables the user to enter the internal space of the screen, projected on the surrounding (walls/floor/ceiling of the room), and browse the images with a high level of immersion [Jones et al. 2014] [Jones et al. 2013].

In both cases, the user cannot see the entire screen, but in the former case, the screen opposite the user is hidden, and in the latter case, the screen behind the user is hidden. In addition, different actions are required for the user to view the hidden surface. In the former case, a small display can be moved by grabbing it by hand or looking into it using the upper body, whereas a medium display can be browsed by walking around it. In the latter case, the user can walk around the display or move his/her head to look at it.

Thus, there is a clear difference in the interaction elements of the two displays. Traditionally, they have been considered to be completely different displays.

However, considering the user's position, the only difference between A and B (Fig.1) is whether the user is outside or inside the omnidirectional screen. In addition, when the image can be projected from the center of A, as shown in Fig.2, the difference between A and B can be considered to be the presence of A.

Therefore, we propose a new omnidirectional display that can dynamically control the omnidirectional projection from a single central point and the transparency of the screen material as well as a new omnidirectional display platform that integrates omnidirectional displays A and B on a single platform. This device not only allows the user to selectively use the interaction elements and features of A and B, but also allows the interaction elements of each system to be extended by the features of the other.

2 PROPOSED SYSTEM

In this study, we first developed the procam shown in Fig.2, which can project more than 180 degrees using an ultra-wide angle lens

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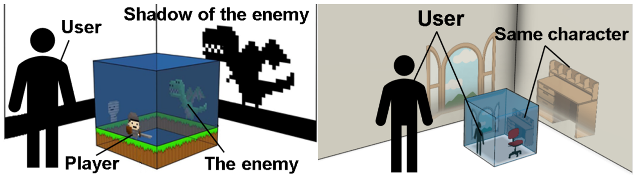

Figure 3: Game App (Left), Edit Interior (Right)

Figure 4: App that uses the features of A and B

instead of multiple procam units, as used in a conventional projection system. We also realized omnidirectional projection from a center point. This solves various problems of conventional multiple procam systems, such as the complexity of calibration, the need for more equipment, and the narrow space available for projection.

Furthermore, this omnidirectional projection from the center point means that if A in Fig.2 is removed, the image will be projected directly onto B. We consider this to be an interesting feature that enables the integration of two different omnidirectional projections (inside and outside) into one. In addition to physically removing and replacing A, the optical transparency of A can be dynamically controlled by PDLC (Polymer Dispersed Liquid Crystal: electrically switched between transparent and opaque status). This makes it possible to generate the above features in whole/in part as needed, and to project to A and B simultaneously or switch between them.

In this paper, we propose a design method for the device and several apps that combine the displays A and B shown in Fig.1.

3 PROTOTYPE

The configuration of the proposed device is shown in Fig.2. The omniprocam unit consists of a projector (BenQ TH682ST), a camera, a fisheye lens, and a beam splitter to align the optical axes of the projector and camera. The proposed device also consists of an omnidirectional display of a 25-cm cube made of five PDLC sheets whose transparency can be varied by voltage, a microcontroller (Arduino) for controlling the PDLC voltage, and a computer for generating images. The vertical synchronization (VSYNC) signal of the VGA signal transmitted from the computer to the projector was input to the Arduino, and the opacity of the PDLC was controlled synchronously. When the PDLC is opaque, it functions as an omnidirectional screen (A of Fig.1). When the PDLC is transparent, images from the projector pass through the PDLC and are projected onto the ambient environment (B). The image projected by the projector alternates between the image projected onto the PDLC (A) and the image projected onto B at 60 Hz. By synchronizing the switching of the transparency and opacity of the PDLC with the output images, we can selectively and simultaneously project independent images on and around the PDLC. The projection on B in Fig.1 is sometimes reflected on A, but this is canceled by projecting the complementary color of the image on B onto A. In addition, PDLC sheets can be bent or cut into rectangular shapes to construct a display A that is similar to the internal shape of B.

4 APPLICATION

First, as described above, an omnidirectional display has a characteristic that there is a "hidden surface" that the user cannot see at a glance. In this regard, we can consider an app that projects the view of the hidden surface of A on the wall (B) behind the hidden surface of A in Fig.1. This would save the user the time and effort needed to go and look at the hidden surface. However, we thought of projecting an image on the wall (B) that attracts the user's interest in the invisible part or inspires fear, depending on the user's detected position. Therefore, we believe it is possible to develop an entertainment app such as a game by triggering the active behavior of the user to investigate or avoid the hidden surface. For example, as shown in Fig.3 (Left), the game presents ambient information on the wall (B in Fig.1), such as shadows of terrifying enemy characters and blood splashes or shadows of enticing treasure chests and twinkling stars, which exist in the area hidden from the user's perspective. This would lead the user away from the fear-inducing objects or toward the interesting objects.

Next, the texture image of a 3D model of B can be browsed /edited (by touching or otherwise interacting with the display) by a user from above while surrounded by A (Fig.3 Right). Simultaneously, the user can experience a highly immersive browsing experience by projecting the image onto B, thereby improving work efficiency.

Finally, we consider an app in which, while an image is projected onto A, A is made transparent so that the image is projected directly onto B, giving the user an immersive experience. For example, as shown in Fig.4, the moment a user touches A where the starry sky is projected, A becomes transparent, and when the user looks up, the starry sky is projected onto the entire room (B).

5 CONCLUSIONS AND FUTURE WORK

In this study, we proposed a new interaction method that integrates the two display types by using PDLC to project an omnidirectional display that can be browsed from inside and outside with a single procam. In this study, we proposed a new interaction method that integrates the omnidirectional display composed of PDLC (A) and the ambient environment (B) on a single procam by selectively and simultaneously projecting independent images to each of them. In future, we will proceed to implement the proposed device, develop its apps, and evaluate the effectiveness of the proposed method.

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