FairLift: Interaction with Mid-air Images on Water Surface

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Figure 1: Left: FairLift. Center: Augmented RealiTea. Right: Sky Lanterns

ABSTRACT

FairLift is an interaction system involving mid-air images, which are visible to the naked eye under and on a water surface. In this system, the water surface reflects the light from micro-mirror array plates, and a mid-air image appears. The system enables a user to interact with the mid-air image by controlling the image position of a light-source display from the water level measured with an ultrasonic sensor. The contributions of this system are enriching interaction with mid-air images and addressing the limitations of conventional water-display systems.

CCS CONCEPTS

• **Hardware → Displays and imagers**; • **Human-centered computing → Displays and imagers**;

KEYWORDS

mid-air interaction, augmented reality, water display, mid-air image

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1 INTRODUCTION

How can we see a fairy standing on our palms? How can we display an image on a transparent water surface? How can we make them "magically" appealing?

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To merge computer graphics and the physical world, we propose the system FairLift that enables users to interact with a mid-air image under and on a water surface. To present a mid-air image, we use micro-mirror array plates (MMAPs) and the reflection of the water surface. To make an experience magically appealing, we shield the optical system from the user's view with a view-control film (VCF). Since the user cannot see the optical system, it is difficult for them to imagine how the system displays the mid-air image. Tracking the water level by using an ultrasonic sensor enables the users to simultaneously scoop up a mid-air image and water with their palms.

FairLift not only enriches interaction with mid-air images, but also solves the limitation of conventional water-display systems. Aquatop Display is an interactive water-display system that enables an image to be projected on a water surface clouded with a large amount of bath salt [Koike et al. 2013]. Water screen is a thin film of water ejected from a pump acting as screen for projection. However, the system sprays water around and prevents people from getting close to the screen. Our system can display a vertically standing mid-air image moving in the three-dimensional space without making the water cloudy and without wetting the surrounding area.

We also solve the problem of occlusion in which real objects that are located deeper than an AR image hide the AR images.

2 SYSTEM DESIGN

FairLift is roughly divided into two subsystems: optical and feedback. The optical subsystem consists of MMAPs [Otsubo 2014], a display (LITEMAX SLD2126 (1600cd/m^2)), water tank, VCF (LINTEC WINCOS Vision Control W-0055), and PC (Asus T303UA). The feedback subsystem tracks the water level and consists of an ultrasonic sensor (Parallax PING) and microcomputer (ARM mbed LPC1768).

The optical subsystem extends the previous system [Yamamoto et al. 2015] using a reflective surface and enables the displaying of a mid-air image under and on a water surface. Figure 3 shows the principle of our proposed system. MMAPs form a mid-air image

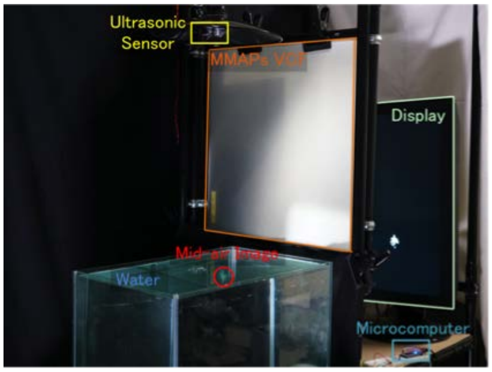

Figure 2: Implementation

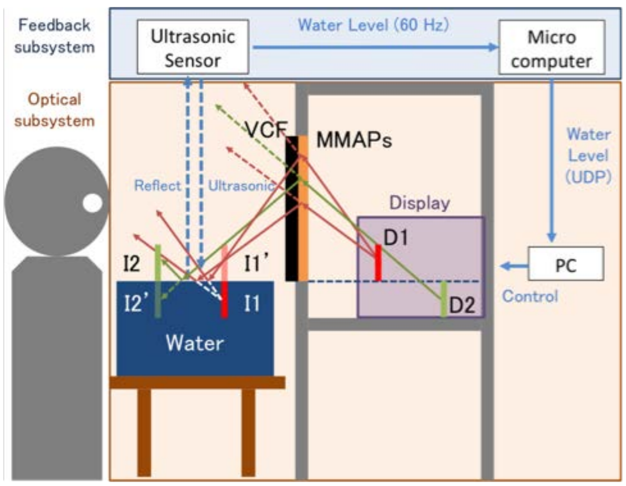

Figure 3: Principle & System Flow

(I1') with light from a light source (D1) located above the water level. The virtual image (I1) of the mid-air image (I1') reflected on the water surface is the underwater image seen by the user. The water surface forms a mid-air image (I2) on the water surface with light reflected from the MMAPs from another light source (D2) located below the water level. When there is no water, the MMAPs form the mid-air image (I2'). Since the light necessary for forming the mid-air image passes only on the water surface, users can see the image superimposed on the real object in the water (Figure 1 left). In addition, since the VCF blocks the light from D1 or D2, which goes straight to the user without being reflected from the MMAPs, the user cannot recognize the space behind the MMAPs. We implement D1 and D2 using a single display installed across the water level. The PC controls an image on the display based on the water level transmitted from the feedback subsystem.

The feedback subsystem transmits the water-level information necessary for interaction with the mid-air image to the optical subsystem. To measure the water level, we use an ultrasonic sensor for measuring the water level of the scooped transparent water surface in a non-contact manner. We install the sensor in a vertically downward direction at the same horizontal position as the mid-air image at a height of 50 cm from the water level of the water tank filled with water. The microcomputer transmits the measured water level to the PC of the optical subsystem using serial communication at 60 Hz.

3 EXPERIENCES

We developed three interaction experiences: FairLift, Augmented RealiTea, and Sky Lanterns (Figure 1). FairLift is an experience for users to scoop up a mid-air image of fairy that appeared on the water surface with their palms. We implemented the experience by changing the fairy position of the display according to the displacement of the water level. Augmented RealiTea is an experience in which the bud of a mid-air image of a flower displayed in a cup gradually blossom as the user pours tea into the cup. At this time, the image of the bud always maintains the same vertical position. We implemented the experience by changing the bud position of the display by twice the displacement of the water level due to pouring the tea. Sky Lanterns is an experience that when a user touches the water surface, mid-air images of lanterns appear floating around a real ship and fluctuate fantastically. The fluctuating water surface disturbs the reflection direction of the light beam forming the mid-air image, and the formed image fluctuates. Using this phenomenon, we present the image of lanterns with natural fluctuation dependent on water.

4 PROSPECTS

The reality that FairLift can augment is not only the static water surface space. For example, the system can present a mid-air image on the water surface of a fountain and a road wet from rain (Figure 4). Furthermore, when physical limitations regarding MMAPs size are solved, we expect that the proposed system will be suitable for different bodies of water such as ponds, riversides, and seas.

Figure 4: Left: mid-air image on water surface of fountain. Right: mid-air image on road wet from rain.

ACKNOWLEDGMENTS

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