Visualization and Interaction of Light Rays through Aerial Imaging

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***Abstract*—In this study, we have developed a novel method that enables the visualization of light rays in the air and interaction with these rays. In this method, the first step involves illuminating light rays in a space filled with mist to visualize the rays within the space. Subsequently, by applying a Micro Mirror Array Plate (MMAP) to the visualized rays, it becomes possible to visualize the light rays in the air without mist. Users can interact with the visualized light rays in the air by touching or moving them with their fingers.**

I. Introduction

In recent years, various types of visual display systems and methods have been developed and utilized, going beyond simple displays to include spherical screens, transparent screens, and head-mounted displays. Among these, there is a growing interest in content that utilizes aerial imagery, creating an illusion as if the images are floating in the air.

One method of displaying images in the air involves directing laser beams or similar sources onto a space filled with mist. This results in the light rays becoming visible in the space. Even when projecting an image composed of points using a projector instead of laser beams, the light rays become visualized. By moving these points or changing their colors in response to user actions, it's possible to achieve interaction with the visualized light rays in the air [1]. However, with this approach, it's necessary for users to enter the space filled with mist, and there could be instances where the mist disperses due to human movements, causing the visualized light rays to disappear. Moreover, mist might also have an impact on sensors used for interaction.

In this study, we propose a method that combines the use of a Micro Mirror Array Plate (MMAP), an alternative technique for aerial image, with the mist-based visualization of light rays within the space. MMAP has an appearance similar to a glass plate, but it possesses the characteristic of focusing objects located on one side of the MMAP onto planar spatial positions. MMAP commonly employs displays as image sources, and various techniques for aerial image projection using MMAP have been developed [2].

In the proposed method of this study, the visualized light rays in the air using mist and a projector are used as the image source for MMAP. This enables the recreation of a state where light rays are projected and visualized in the air without mist. Moreover, various interactions with the visualized light rays in the air can be achieved. For instance, projected images can change in response to user actions, and sounds can be generated corresponding to direct interactions with the light rays, enabling a wide range of interactions through the visualized light rays in the air.

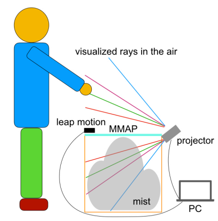

Fig. 1. System configuration of the proposed method.

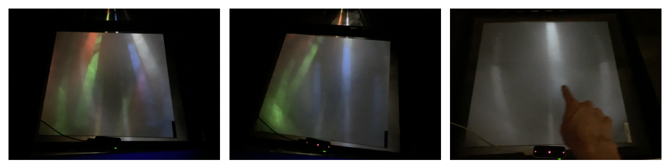

Fig. 2. Experimental results.

II. Methods

Fig. 1 shows the system configuration of the proposed method. Mist is filled inside the box, and an image composed of points is projected onto it using a projector. This results in each point being visualized as a light ray. Then, an MMAP is placed on top of the box, causing the light rays visualized within the mist to be projected into the airspace above the MMAP. Positioned on top of the MMAP is a Leap Motion device capable of 3D tracking of the user's finger positions. This enables understanding the spatial relationship between the fingers and the light rays. Consequently, by altering the projected image based on the user's finger positions, interactions such as generating light rays in the air, allowing fingers to interact with the rays, and producing sounds upon touch can be realized.

III. Experiment

We conducted an experiment using a prototype system that implemented the proposed method (Fig. 2). We confirmed that light rays visualized by mist under the MMAP were observed in the air. We also confirmed that the position of the visualized light rays in the air could be interactively altered based on finger movements.

References

[1] N. Kotani, S. Mizuno, "A Proposal of Interactive Projection Mapping by Touching Rays Visualized by Smoke", Proc. of NICOGRAPH International 2019, P08, 2019.

[2] Y. Matsuura, N. Koizumi, "FairLift: Interaction with Mid-air Images on Water Surface", SIGGRAPH 2018 Emerging Technology, 2018.