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Aerial Displays Based on Dynamic Projection Mapping on Drones

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ABSTRACT

Recently, aerial display technologies have fascinated people. Dynamic projection mapping on drones is one way to achieve such aerial displays. In this paper, methods to achieve dynamic projection mapping on a flying screen by drones using high-speed optical gaze controller are introduced.

1 Introduction

In the world of science fiction, technologies that allow to appear images in the air have been depicted, and such technologies have fascinated people. To realize such technology, various methods have been studied to realize such technologies in the real world.

In recent years, aerial display technology using drones has been actively developed. For example, Intel Corporation has provided Shooting Star, a technology that displays 3D images in space by flying a large number of small drones equipped with high-luminance LEDs[1]. NTT DOCOMO is developing a floating spherical drone display that uses an afterimage display[2].

The preceding studies often use a drone equipped with a light source to fly, but this method has the disadvantages that the drone tends to be heavy, which increases the risk of a crash, and that energy must be supplied from the drone to the light source. Considering dynamic projection mapping techniques have also been attracting attention in recent years[3], dynamic projection mapping on drones is another way to achieve.

From the above, we have been studying methods of projecting images onto drones and utilizing them as aerial displays. In this paper, we first describe saccade mirror 3, the basic technology that enables our approach, and then describe developed aerial display methods based on it.

2 Saccade Mirror 3 and 180 projector

A Saccade Mirror 3[4] has a structure in which three rotating mirrors and a pupil shift lenses are placed in front of the camera as shown in Figure 1. The pupil shift lenses are an optical system that transfers the entrance pupil of the camera to the space in front of the camera where the mirrors are placed. Due to this structure, even a small mirror can reflect all the incident light rays to the camera.

As shown in Fig. 1, the three rotating mirrors are combined to control the gaze direction, and in principle, the panning direction can be controlled in 360 degrees. This is achieved by the fact that the rotation axis of the mirror, indicated as M3, makes a constant angle with the mirror surface. Note that this mechanism has three rotating mirrors and its degrees of freedom (DOF) is three. This is redundant to the two DOF of the gaze direction. This configuration was adopted in order to secure two DOF in the gaze direction even when there is a singular posture in which two of the three mirrors degenerate in a particular gaze direction[4].

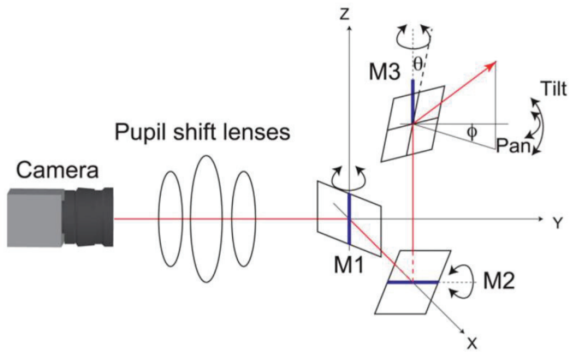


Fig.1 Structure of Saccade Mirror 3[4].

The photograph of the prototype of Saccade Mirror 3 is shown in Fig. 2. This prototype has two camera ports that share an optical axis using half-mirror. In our study, a high-speed vision was mounted on the first port and a projector was mounted on the second camera port, so that the projection area of the projector and the field of view (FOV) of the vision always match, and the projection direction can be controlled as fast and as widely as the gaze direction. The projection system composed of the saccade mirror 3 and a projector was named *180 projector*[5].

3 Aerial display based on the 180 projector

We demonstrated a drone based aerial display using the 180 projector. The system connections are shown in the Fig. 3. A drone (MavicMini, DJI) with a screen attached was used as the projection target. A white balloon fixed on a hemispherical styrofoam covered with retroreflective materials was adopted as a screen. The retroreflective material was used as the tracking target since it appears very bright, which makes the visual recognition easier.

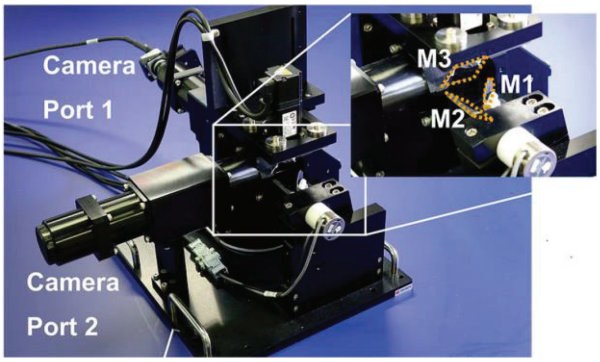


Fig. 2 Photograph of the Saccade Mirror 3[4]

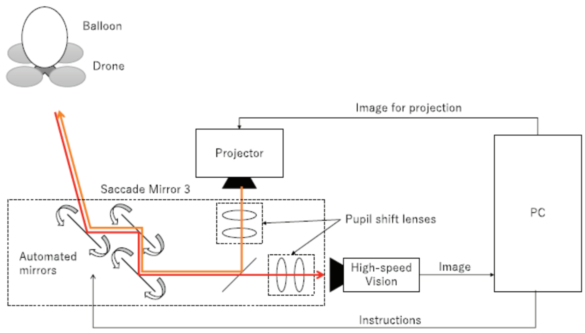


Fig. 3 System connections of the aerial display based on the 180 projector[5]

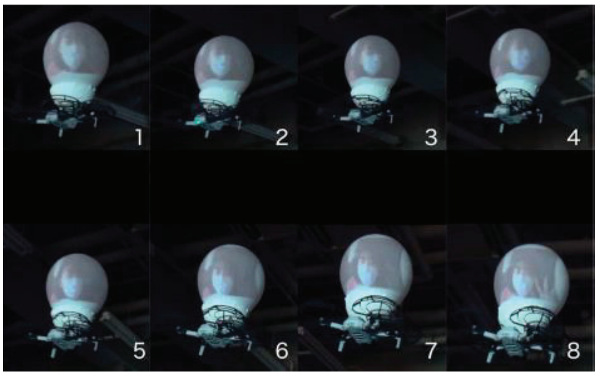


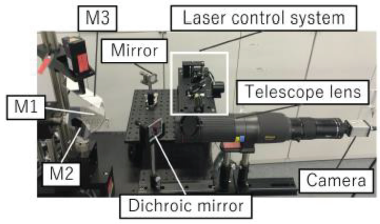
Fig. 4 Sequence of photographs of projected image on a flying drone in the projection experiment over 180 degrees in pan angle[5].

We confirmed that the system was able to keep projecting the image towards the target as in Fig. 4 while tracking. Note that the time from 1 to 8 in Fig. 5 was about 3 seconds.

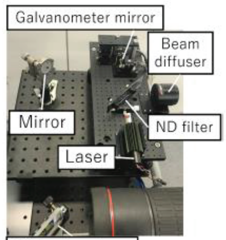
This result indicates that an aerial display is feasible by projecting images onto a drone. However, the above system was able to only project to a distance of about 2-3 m, making it difficult to realize a large display.

4 Basic Study for Large Aerial Display

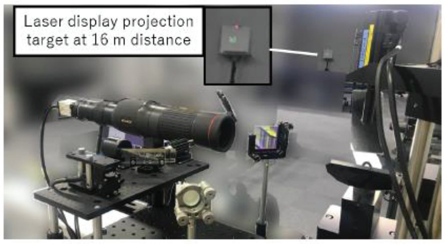
Given the attention drone shows are attracting, it is expected that there will be demand for larger aerial displays. To achieve larger aerial displays, images must be projected over greater distances. To achieve this, we are building a new system to realize projection over a long distance[6]. The current prototype system consists of a telescope-type high-speed gaze control system that was able to track an object at a distance of 200 meters and a simple laser projector. The telescope-type high-speed gaze control system consists of three rotational mirrors and a camera with telescope lens. The simple laser projector is composed of a green laser and XY galvano-scanner. Photographs of the prototype system are shown in Fig. 5.



(a) Overview of the system



(b) Laser control system



(c) System and projection target

Fig. 5 Photographs of the prototype system for long range projection[6].

As a preliminary experiment, a screen was set at a distance of approximately 16 m from the system to check whether dynamic projection mapping could be achieved by an operator moving the screen. A sequence of photograph during this experiment is shown in Fig. 6. It was confirmed that the laser beam was projected even when the screen was moved.

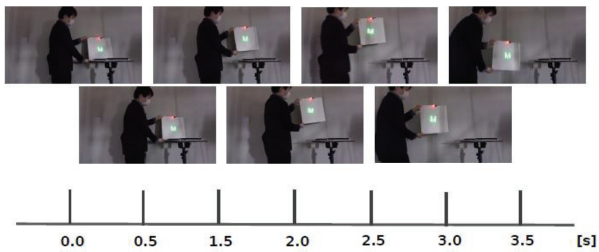


Fig.6 A sequence of photographs of dynamic projection mapping on a moving screen with a distance of 16 m[6].

5 Conclusion

This paper introduces the aerial display principle using dynamic projection mapping on a drone. Long range projection in particular is still under study, and we plan to create larger aerial displays in the future.

Acknowledgement

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