Gushed Light Field:
Design Method for Aerosol-based Fog Display

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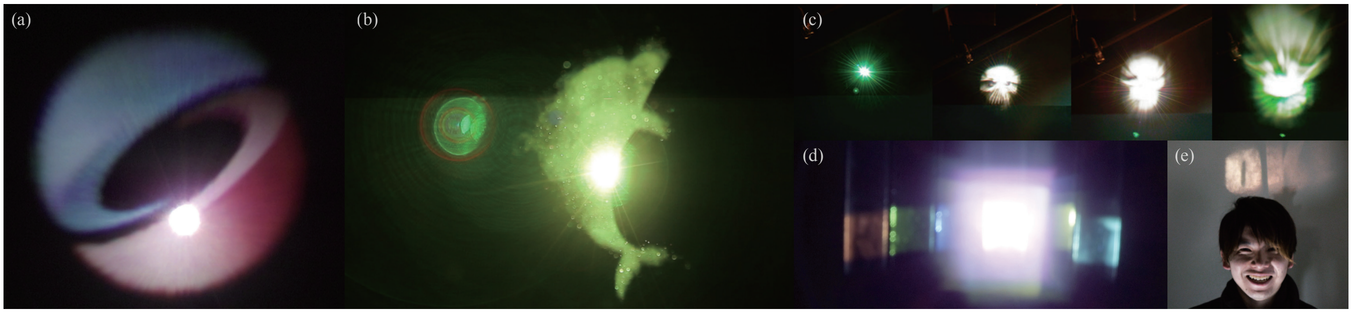

Figure 1: *Application examples of Gushed Light Field. (a) Showing SIGGRAPH logo. (b) Showing a dolphin. (c) "Gas Ghost" - installation in the lobby of the music club. When a person came close to the projection point, the system renders an aerial image of a skull. (d) Multi-viewpoint aerosol-based fog display. (e) A vision of our wearable system (showing "OK" above man's head).*

Abstract

We present a new method to render aerial images by aerosol-based fog screens. Conventional fog screens are easily affected by the air flow and their generator occupy large areas. In this study, we propose to add new tradeoffs between limited display time and payloads. We employ aerosol distribution from off-the-shelf spray as a fog screen that can resist the wind, and has high portability. We present some application example; wearable application, multi-viewpoint display, display embedded in the environment, and aerial imaging with drone or radio-controlled model car. This study will contribute to the exploration of new application areas for fog displays and expand expressions of entertainments and interactivity.

Keywords: Display, fog screen, projection, aerosol, design.

Concepts: •**Hardware** → **Displays and imagers;**

1 Introduction

The fog screen [Rakkolainen et al. 2005] has been used as main diffusers of passive aerial display. In this kind of display system, the fog is generated by the fog generator, and the projector projects images onto the fog. These systems aimed to realize fixed, large, and long display time. However, there are some problems with these systems. The first relates to the size of the system; the fog generator is large and heavy. The second problem is the low wind-tolerance. This system cannot project the image in a windy place or cannot be used with moving objects, because conventional fog screen is easily affected by the air flow. Both of these problems are related to mobile situations. In addition, a fog generator cannot generate fog in a short time, and the fog cannot rapidly disappear. Therefore, we cannot move this system as a wearable display or cannot project an image instantly.

In this paper, we propose to add new tradeoffs between limited display time and payloads. We employ aerosol distribution from off-the-shelf sprays as a diffuser (Figure 1 (a)(b)). By introducing aerosol sprays, we can solve problems inherent with the conventional fog screen in some cases. Using aerosol spray has two merits. First, because of its high refresh rate, the system and projected image can be moved, and it has high wind-tolerance. Second, because the ingredients of the spray evaporate immediately, we can project an image instantaneously. We also enable the whole system to be lightweight and compact.

We present applications that utilize the benefits of our aerosol-based display: high refresh rate, small size and lightweight, high tolerance for wind, and selective narrow viewing angle.

2 System overview

Figure 2 (a) shows the system overview of our basic setup. This setup includes an aerosol spray, servomotors for operating the spray, microcontrollers, a mirror controlled by a servomotor, the laser portable projector, a battery, and frames. The minimum weight of this is around 600 g (when we use balsa wood for frames). Assembled basic system with acrylic plates is shown in Figure 2 (b).

Aerosol spray: An off-the-shelf cooling spray which aims at cooling human bodies was used as a projection medium (Figure 2 (c) left). Because these are high-volatility ingredients, they do not remain on surfaces of objects like floors or walls. Figure 2 (c) right is fragrance-free air freshener that has wide nozzles, however, it is too large and heavy. We use this spray on some applications when we have not to consider weight or size.

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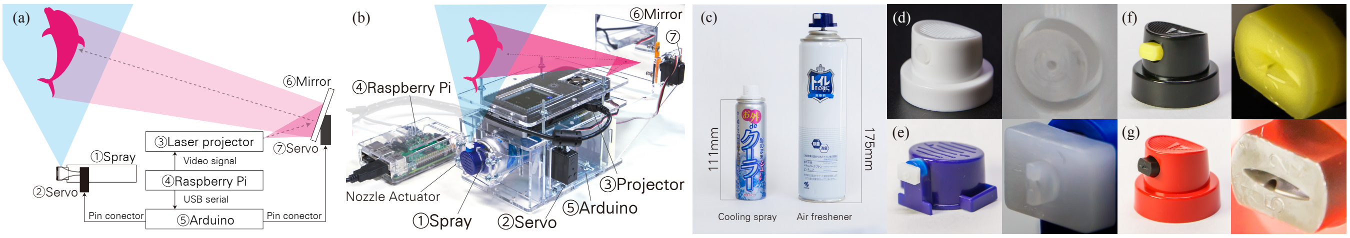

Figure 2: *(a) System overview and data-flow diagram. (b) System appearance (acrylic plate version). These parts were formed with a laser cutter. (c) Aerosol sprays. Left: instant cooling spray. Right: fragrance-free air freshener. (d)(e)(f)(g) Closeup photos of nozzles. (d) Nozzle of cooling spray. (e) Nozzle of air freshener. (f)(g) Nozzles for graffiti (aerosol art).*

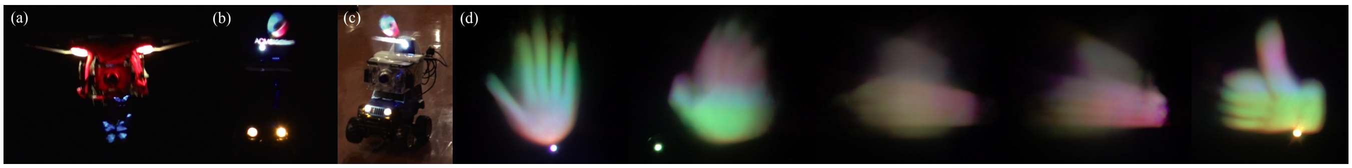

Figure 3: *(a) An floating aerial image (showing a morpho butterfly) under the drone (DJI Phantom 2; DJI Co., Ltd.). (b)(c) A radio-controlled model car with our system. (d) Multi-viewpoint aerosol-based fog display. The camera is moved right to left focusing on the same position.*

Spray nozzles: We considered combinations of nozzles and aerosol sprays. Nozzles for graffiti (aerosol paint, street art) is considered because there are many types of nozzles (*e.g.*, for calligraphic effects (Figure 2 (f)), for fill-ins and large surfaces (Figure 2 (g))). However, it is not suitable for our system because their distributions are short and not so wide. We employ nozzles for air freshener (Figure 2 (e)) instead of nozzles for cooling spray (Figure 2 (d)).

3 Applications

Floating or fast moving midair display: We fabricated a prototype of the application installed on a drone (Figure 3 (a)). The system can be installed on a small drone easily because our system is around 600 g at the smallest including all components. We also can install our system on a radio-controlled model car (Figure 3 (b)(c)). We can show an aerial image by using the instantaneous feature of the system. This will attract the attention of the viewers.

Wearable use: We present wearable uses of our system as a proof of concept on the advantages of the movability and lightweight. If we use a conventional fog screen, users cannot move swiftly, as it causes air movement which can distort the fog screen. We can use our system as a wearable display in performances and a situation of communication. People can project aerial images over their heads or their back and communicate with others (Figure 1 (e)).

Multi-viewpoint aerosol based fog display: We implemented multi-viewpoint aerosol display, which brings motion parallax to observers like [Yagi et al. 2011]. A prototype of this application is shown in Figure 1(d). We used a DLP projector and 6 mirrors to project images from various angles. Aerosol distribution shows forward scattering, and its form likes a cylinder. This technique enables users to create multi-view aerial image instantly.

Display embedded in the environment: We developed another application in which an aerial image suddenly appears and disappears. We suggest "Gas Ghost" as a specific example. We practically incorporated it into the decoration of a live music club's lobby (Figure 1 (c)). When a person came close to the projection point, the system emitted aerosol and projected an aerial skull image. Audiences could see it appear suddenly. Some of the audience was screaming and escaping. We can also combine embedded and multi-viewpoint display. Our system can show different information to each side as shown in Figure 3 (d).

4 Discussion

Risk: The aerosol may get into a persons eye or mouth directly depending on the style of use. In addition, the environmental impact of aerosol sprays should be considered. Even if there are few negative effects of cooling spray for humans, the spray has an ingredient that may be connected with environmental destruction or has toxicity. Another problem regarding safety is that the spray is flammable. If our system is used in a fire scene, the spray could ignite or cause an explosion. Moreover, careful attention should be taken when using the system with real fire of stage effects.

Spray performance: A problem of the spray performance is pressure of gas. It causes three problems. The first problem is stability of the image. Our display shows the image flickering. Therefore, we cannot see the whole image on only one frame. However, we can see it in continuous scene because of residual image effects. The second problem is that the angle of aerosol distribution is narrow. An area of the screen is small. The last problem relates to the wind-tolerance. Our system has high wind-tolerance, however there is a limit (approx. 10m/s). If we increase the gas pressure, a screen of our system would always maintain its form and these problems might be solved. However, we also have tradeoffs between increasing pressure and reducing the volume of the spray. Sprays should be used for different purposes in accordance with the use.

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