MistFlow : A Fog Display for Visualization of Adaptive Shape-Changing Flow

Kazuki Otao
University of Tsukuba
kaootao@gmail.com

Takanori Koga
National Institute of Technology, Tokuyama College
koga@tokuyama.ac.jp

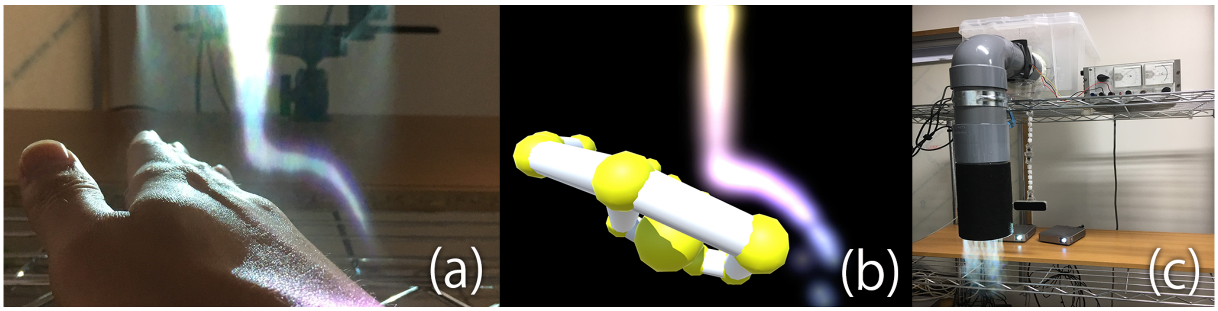

Figure 1: (a) Fog screen deformation by user's hand and flow visualization. (b) Physical simulation of the deformation of fog by using a particle system and rigid body model. (c) Overview of the fog display.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**; *Visualization*;

KEYWORDS

fog display, aerial projection, visualization, feed-forward approach, interactive arts

1 INTRODUCTION

A fog display has distinctive properties such as being translucent and virtually immaterial; and it enables natural interaction between aerially projected images and users. Recently, many studies on fog displays and its application have been conducted owing to its exciting prospects [Lee et al. 2009] [Yagi et al. 2011]. Although many researchers realized interesting interactions between a touching motion and aerial images [Rakkolainen et al. 2005] [Lam et al. 2015], there has not yet been an experiment that explicitly takes advantage of the relationship between the physical flow of the screen and the projected image associated with it. One of the reasons is that it is difficult to detect the deformation of screen shape (i.e. fog flow) caused by user's action in real-time.

Mistform [Tokuda et al. 2017] is one potential solution to address this problem. These scientists and engineers proposed a machine-learning-based method to predict the shape of the fog screen, and enable projection onto the shape-changing screen. Furthermore, by dynamically changing the shape, it can provide 3D perception. However, it also does not detect the physically deformed shape of the screen by user's action perfectly.

SA '17 Posters, November 27-30, 2017, Bangkok, Thailand

To cope with this problem, we propose a feed-forward approach to create pseudo-synchronized image contents with the deformation generated by users. In the proposed method, a sense of natural synchronization between the shape-changing screen and the projected image is provided by using hand gesture detection and a physical simulation of collision between falling particles and user's hands. It also aims to realize a natural interaction between the fog screen and users' actions by using this feed-forward approach. In this paper, we describe the detailed configuration of the proposed system and the results from a user study.

2 SYSTEM OVERVIEW

Figure 2 shows a block diagram of the proposed system. Indeed, the key point of the proposed method is to use a feed-forward calculation approach that approximately simulates the collision between falling particles and a detected user's hand in a virtual world. Instead of conducting an accurate fluid simulation, we used an approximate simulation with a particle system and a rigid body model. To realize a real-time natural interaction system, we finely tuned the parameters of the simulation engine.

Hardware of fog display. We made a fog display hardware by referencing the design of [Yagi et al. 2011]; and Fig. 1(c) shows its overview. Although their system provides a multi-point view, we simplified it into a single-point view system in this study. The shape of the fog screen is semi-cylindrical as shown in Fig. 1(a).

Hand gesture detection. To detect the position and shape of the user's hands, we used *Leap Motion*. The detected position and shape were converted into a rigid body model in a virtual world for the physical simulation.

Simulation by physical engine. To simulate the shape-changing flow of the fog screen, we implemented a particle system with the physical engine included in *Unity*. The particle system consists of

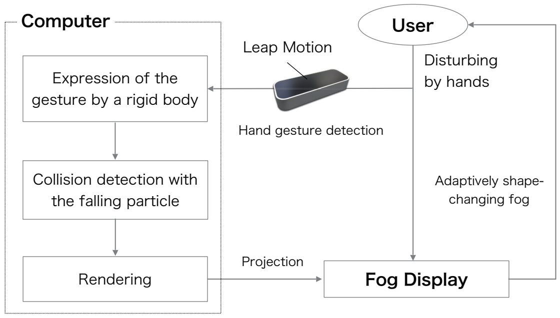

Figure 2: Block diagram of the proposed system.

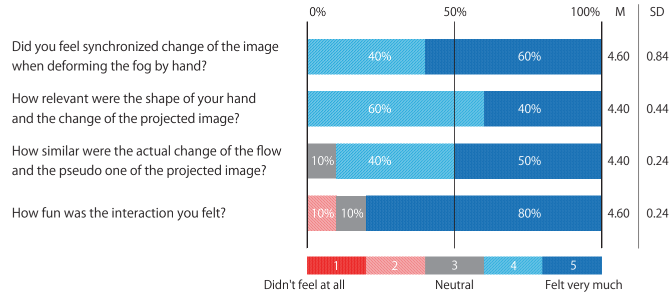

Figure 3: Questionnaire items and answers.

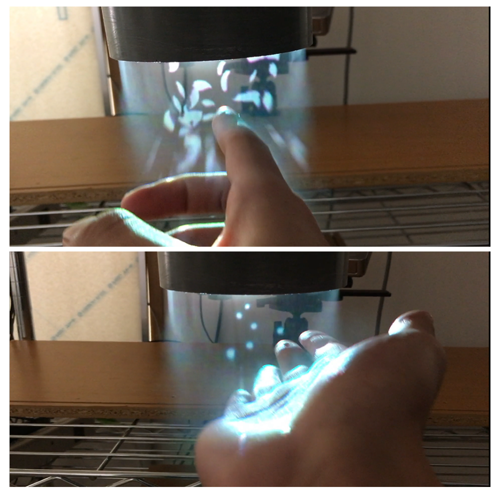

Figure 4: Application to interactive arts. (Top) Shower of cherry petals. (Bottom) Snowfall.

both *Emitter* and *Particle*. *Emitter* reproduces the position of the nozzle of the fog screen and generates the particles. *Particle* is a set of small primitive spheres and has physical parameters such as mass, friction, restitution, etc. Although the generated particles fall according to a gravitational parameter, they collide in relation to the user's hand shape and bounce back. This is consistent with the deformation of the real fog screen as shown in Figs. 1(a) and 1(b).

3 RESULT OF USER STUDY

We conducted a user study with 10 participants (7 males and 3 females, aged fifteen to twenty-five). The participants were instructed to stand in front of the fog display and to see how consistent the flow of the fog screen and that of the projected image were when disturbing the flow by hand. After that, they were asked to answer to a five-tiered questionnaire and describe their experience in their own words. The items and results are shown in Fig. 3. The results were positive for all items. Despite the approximated simulation with the rigid body model, almost all participants felt a sense of natural synchronization between the shape-changing screen and the projected image. In the free description column, the following comments were obtained.

- We can experience natural interaction easily and intuitively.
- Strictly speaking, it is not accurate physical reproduction of the real flow.
- It was fun to actually touch and play.

Although physically accurate reproduction of the flow was not realized, the approximation produced a natural interaction between the fog screen and users' actions using the feed-forward approach.

4 APPLICATION AND FUTURE WORK

We applied the proposed method to interactive arts to verify its effectiveness and applicability. Figure 4 shows two attractive examples. The top and bottom figures show a shower of cherry petals (i.e. 'Hanahubuki') and snowfall, respectively. The users can enjoy changing the behavior of those objects not only by touching and letting them pile up on the palm of their hands, but also by stirring the flow.

Our future work is to synchronize the feel of the flow with the image contents by introducing a precise control of the fog display's blowing flow.

ACKNOWLEDGMENT

This research was supported by JSPS KAKENHI Grant Number 16K21580.

REFERENCES

Miu-Ling Lam, Yaozhun Huang, and Bin Chen. 2015. Interactive Volumetric Fog Display. In *SIGGRAPH Asia 2015 Emerging Technologies (SA '15)*. ACM, New York, NY, USA, Article 13, 2 pages. https://doi.org/10.1145/2818466.2818488

C. Lee, S. DiVerdi, and T. Hollerer. 2009. Depth-Fused 3D Imagery on an Immaterial Display. *IEEE Transactions on Visualization and Computer Graphics* 15, 1 (Jan 2009), 20–33. https://doi.org/10.1109/TVCG.2008.83

Ismo Rakkolainen, Stephen DiVerdi, Alex Olwal, Nicola Candussi, Tobias Hüllerer, Markku Laitinen, Mika Piirto, and Karri Palovuori. 2005. The Interactive FogScreen. In *ACM SIGGRAPH 2005 Emerging Technologies (SIGGRAPH '05)*. ACM, New York, NY, USA, Article 8. https://doi.org/10.1145/1187297.1187306

Yutaka Tokuda, Mohd Adili Norasikin, Sriram Subramanian, and Diego Martinez Plasencia. 2017. MistForm: Adaptive Shape Changing Fog Screens. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*. ACM, New York, NY, USA, 4383–4395. https://doi.org/10.1145/3025453.3025608

Asuka Yagi, Masataka Imura, Yoshihiro Kuroda, and Osamu Oshiro. 2011. 360degreee Fog Projection Interactive Display. In *SIGGRAPH Asia 2011 Emerging Technologies (SA '11)*. ACM, New York, NY, USA, Article 19, 1 pages. https://doi.org/10.1145/2073370.2073388