atmoRefractor: Spatial Display by Controlling Heat Haze

Toru Kawanabe
Waseda University

Tomoko Hashida
Waseda University

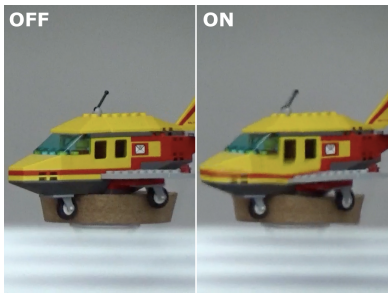

Figure 1: *Superimposing heat haze*

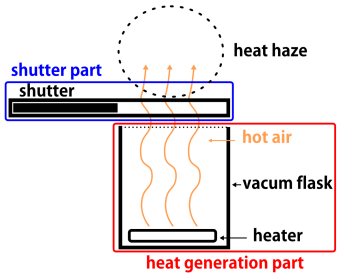

Figure 2: *System Design*

Figure 3: *Guiding the user's gaze*

1 Introduction

In recent years, there has been rapid development of techniques for superimposing virtual information on real-world scenes and changing the appearance of actual scenes in arbitrary ways. We are particularly interested in means of arbitrarily changing the appearance of real-world scenes without the use of physical interfaces such as glasses or other devices worn by the user. In this paper, we refer to such means as spatial displays. Typical examples of spatial displays include a system that can change the transparency or physical properties of buildings [Rekimoto, 2012] and a system that projects video images [Raskar, 2001]. However, those systems have restrictions such as requiring some kind of physical interface between the user and the scene or not being usable in a well-lit environment. Taking a different approach, we turned our attention to a natural phenomenon referred to as heat haze, in which the appearance of objects is altered by changes in the refractive index of air caused by differences in temperature distribution. We propose the atmoRefractor, a system that can generate and control heat haze on a small scale without an additional physical interface such as lenses. That locally controllable heat haze effect can be used to direct attention by changing the appearance of certain parts of scenes.

2 atmoRefractor

The atomoRefrector offers three core technical innovations. One is implementation of a spatial display that can change the appearance of a scene without a physical interface indoors or outdoors by designing a mechanism for arbitrarily generating and controlling heat haze. This mechanism comprises a heat generation part for heating air and a shutter part for controlling the release of the hot air (Fig. 2). The heat generator uses a 100-ohm nichrome wire as a heating element for heating air to 140°C, which is sufficiently high relative to the ambient air temperature of 25°C to create optical refraction that is detectable by the human eye. The shutter consists of a cover that can be opened and closed by a motorized slider (100 mm 2 UNIT WITH MOTOR SLIDE POTENTIOMETERS, manufactured by the Top-Up Industry Corporation) in about one second. The production of heat haze can be controlled by operating the shutter to release or contain the hot air. Another technical innovation is to enable local control of where the heat haze is generated by arranging multiple heat haze generators in an array.

The final innovation is the production of heat haze at an arbitrary location within the user's visual field. User eye-tracking is done by using information obtained with a depth-sensing camera (Kinect for Windows v. 2) placed in front of the heat haze generator and the face tracking function of the Kinect for Windows SDK 2.0. That makes it possible to know where in the user's visual field the heat haze generator is located so that heat haze can be produced at any place in the visual field.

3 Applications and Future Work

We applied this technology to develop three applications, one of which is extending the real world. By superimposing heat haze over an object at an arbitrary location, the appearance of that object can be changed even though the actual shape of the object is not changed. It is thus possible to provide supplementary information on the real world. In this application, we can confirm from the picture on the right side of Fig. 1 that an airplane existing in the real world can be made to appear to waver. Another application is indication of direction, in which a horizontal array of heat haze generators is used to produce heat haze that seems to move from one end of the array to the opposite end, thus indicating a direction to the user. The third application is guiding the user's gaze (Fig. 3). Heat haze creates a constant wavering appearance that has a strong attention-drawing effect. That property can be used to induce the user to look in a desired direction by generating heat haze. Specifically, the user's gaze can be directed toward a preset target object by using eye tracking to determine the user's current line of sight and then generating heat haze between the current line of sight and the target object.

In future work, we plan to use finer control of light refraction to enable effects such as inversion of objects as well as simple blurring and shimmering effects.

References

REKIMOTO, J. 2012. Squama: modular visibility control of walls and windows for programmable physical architectures. In *Proceedings of the International Working Conference on Advanced Visual Interfaces* (AVI '12), ACM, 168-171.

RASKAR, R., WELCH, G., LOW, K., AND BANDYOPADHYAY, D. 2001. Shader Lamps: Animating Real Objects with Image- Based Illumination. In *Eurographics Workshop on Rendering*, 89–102.

SIGGRAPH 2015 Posters, August 09 – 13, 2015, Los Angeles, CA.
ACM 978-1-4503-3632-1/15/08.
http://dx.doi.org/10.1145/2787626.2792611