Multi-Focal Compound Eye: Liquid Lens Array for Computational Photography

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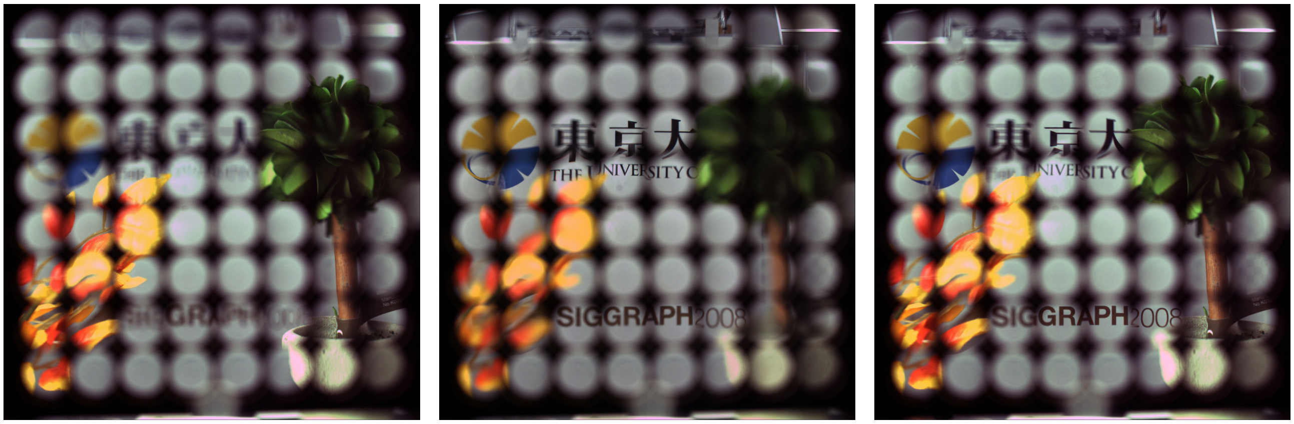

Figure 1: *Experimental results. Constant focal lengths are set to all lenses in the left and center images. Auto-focusing is applied to each lens in the right image, where both the nearer and the farther objects are clearly in focus.*

We developed a novel imaging system that captures images through an array of variable-focus lenses. Since the focal length of each lens can be controlled independently, the system is called a ”Multi-focal compound eye”.

Background

Several compound-eye cameras were developed for various applications such as image-based rendering and digital refocusing [Yamamoto et al. 2004; Ng et al. 2005; Georgiev et al. 2006]. However, those systems were implemented by using fixed-focus lenses. Furthermore, by using dynamic optical devices, our system introduces the concept of Programmable Imaging [Nayar 2006] to compound-eye cameras.

Implementation

As shown in Fig. 2, the system consists of an array of 64 liquid lenses and a high-resolution video camera behind it. Each lens is 7.75 mm in diameter, and its focal length can be quickly changed by using electric signals [Berge and Peseux 2000]. We compactly arranged them on a planer board in an 8 by 8 matrix, which is 66 mm in width and height. To provide an independent focus control, we wired various electric lines. The video camera takes images through the array with 2048 by 2048 pixels at 15 fps.

Experiment

We implemented an auto-focusing method for each of the lenses: the better focal length for its viewing scope is selected from two candidate values. The experimental results are shown in Figure 1. The left and center images are captured with constant focal lengths set to all lenses. Here, only the nearer/farther objects (flower and tree/background logos) are clearly in focus, respectively. In contrast, the right image is captured from the same scene with auto-focusing.In this case, both objects are captured in focus. Another possible application is image-based rendering, and its basic concept is described in [Ueda et al. 2008].

We believe our new imaging system will greatly extend the potential of compound-eye cameras for various applications. Finally, we express our special thanks to Prof. Hiroshi Harashima for the valuable discussions.

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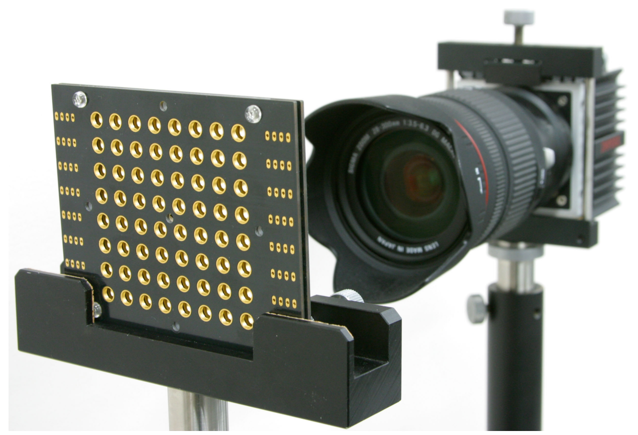

Figure 2: *Appearance of system.*

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