Photochromic Sculpture : Volumetric Color-forming Pixels

Tomoko Hashida*
The University of Tokyo

Yasuaki Kakehi
Keio University

Takeshi Naemura
The University of Tokyo

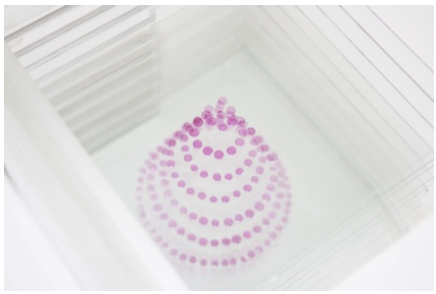

Figure 1: *Volumetric color-forming pixels*

Figure 2: *Multicolored display*

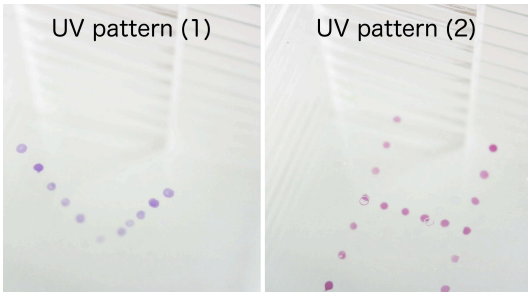

Figure 3: *Controlling UV illumination patterns*

1 Introduction

In contrast to light-emitting displays like plasma display panels (PDPs) and liquid crystal displays (LCDs), color-forming displays like "E-Ink" which displays information by reflecting surrounding light are being actively researched as a technology that is easy on the eye and can even be applied in bright places such as outdoors in sunlight. Applying photochromic materials (PM) for controlling color in this manner, Photochromic Canvas [Hashida et al.2010] and Slow Display [Saakes et al.2010], which are combined with projected-light systems, make it possible to control color without contact with the surface of an object. In this paper, the concept, namely, "contactless color control," is extended to volumetric space, and "volumetric color-forming pixels" are successfully created. This paper proposes a system referred to as "photochromic sculpture" which can generate a dynamically changeable 3D sculpture. (see Figure 1).

2 Photochromic Sculpture

Photochromic sculpture consists of two parts: a presentation part composed of laminated plates coated with PM granules and a control part for manipulating projected light. As for the PM, Spiropyran, which produces color under ultraviolet light (UV) and returns gradually to colorless and transparent when the UV light is blocked, is used. In detail, five types of PM were used: PSP-7, 12, 21, 24, and 33 purchased from Yamada Chemical Co., Ltd. Each PM requires a different time for producing and loosing its respective color. As the transparent plates on which the Spiropyran is coated, glass which transmits UV is used. For the UV source, a long wavelength in the invisible range (i.e., 365 nm) is used.

In regard to the photochromic sculpture system, the following three technological innovations are noteworthy. First, introducing a structure with high transparency makes it possible to create a simple presentation part which does not require electronic control. Accordingly, it is possible to design the presentation part on various scales. Second, controlling the time and strength of the UV illumination makes it possible to control various colors synchronously. That is, by controlling the strength and time of the UV illumination in accordance with each type of Spiropyran with different response times for each color, it is possible to produce and eliminate the intended color at the intended timing. Third, the position of the produced colors is controlled three-dimensionally according to the pattern of the projected UV light. To do this, the granulated PM is arranged in such a way that it does not appear to be stacked up from the viewpoint of the UV-light source.

As described in [Parker 2009] and [Barnum et al.2010], this innovation is an application of a method for controlling 3D images with a 2D projector to color-production control by UV light.

3 Experimental Results and Future Works

A prototype system, composed of 10 laminated glass plates (10 × 10 cm) spaced 1 cm apart, was constructed. The PM was coated on the glass plates in a pattern of 3-mm-diameter dots. An example of a written 3D geometrical pattern (in this case, a cone) is shown in Figure 1. As shown in this example, the 3D geometrical pattern can be viewed from various angles when the transparent cube containing it is held in the hand. An example of a glass "photochromic sculpture" formed by using Spiropyran of five different colors is shown in Figure 2. An example of projecting a different UV pattern for the same presentation part is shown in Figure 3. In this manner, the photochromic sculpture can be dynamically changed in accordance with the projected pattern of UV light from the control part.

A system called "photochromic sculpture"—for controlling volumetric color-forming pixels with a UV-light pattern—was proposed and implemented. Photochromic sculpture can display "volume data" by producing pleasing colors even in bright places. At present, aiming at projection control of more complicated UV patterns, development of a UV projector using a "digital micro-mirror device" is progressing well. Moreover, investigation aiming to create larger-scale photochromic sculptures in outdoor locations in the same manner as the sundial principle—namely, using sunlight which contains a considerable amount of UV light as the light source—is underway [Hashida et al.2011].

References

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*e-mail: photochromic@nae-lab.org

SIGGRAPH 2011, Vancouver, British Columbia, Canada, August 7 – 11, 2011.
ISBN 978-1-4503-0921-9/11/0008