Demonstration of ChromoCloth: Re-Programmable Multi-Color Textures through Flexible and Portable Light Source

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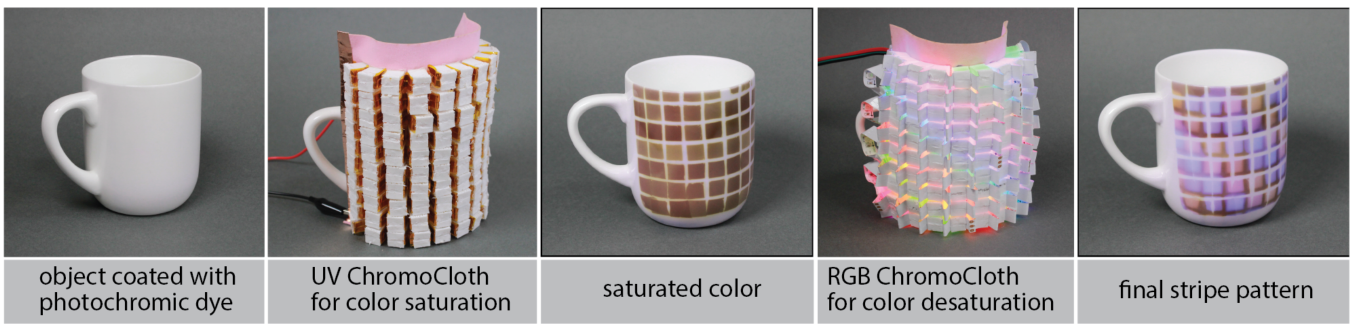

Figure 1: We can create reprogrammable multi-color textures on an object coated with photochromic ink by covering it first with the UV ChromoCloth to fully saturate the color, and then with the RGB ChromoCloth to desaturate each color-channel partially to achieve the target color.

ABSTRACT

In this demo, we present ChromoCloth, a flexible and portable light source for reprogrammable multi-color texture on photochromic objects, whose color can be reprogrammed with external light sources. While prior work used external projectors to trigger the color change, ChromoCloth initiates the color change by covering the object. ChromoCloth consists of a textile substrate, 3D printed diffusive housing glued on top of the substrate and a flexible LED strip that is weaved through the housings.

CCS CONCEPTS

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

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KEYWORDS

digital fabrication; programmable textures; photochromic dyes

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1 INTRODUCTION

Being able to change the color of a physical object as easily as a digital model is an important part of the vision of a dynamic physical world (The Perfect Red [2]). Recent work on reprogramming the appearance of physical objects demonstrated the new opportunities for reprogramming the appearance of phone cases, and shoes [4], or as a passive display, such as a mug that displays the user's daily schedule [6].

Researchers have developed different methods to reprogram colors, such as using electrochromic [3] and thermochromic [1, 5] dyes. While these approaches only enable the transition between two colors, Photo-Chromeleon [4] proposed a method to achieve a large color gamut using photochromic dyes. By spraying a mixture of cyan, magenta, and yellow photochromic dyes on the object and using light patterns of specific wavelengths to saturate and desaturate individual color channels, researchers have shown that they can achieve high-resolution multi-color textures.

One limitation of the prior work that uses photochromic dyes to achieve a large color gamut is that it needs an external projection system that contains UV light. This requires an enclosed space larger than the object to reprogram, a turn-table to rotate the parts of the object in and out of the projection range, and a 3D scan of the object for the system to calculate the projection algorithm. This makes it challenging to reprogram the color of large objects and objects with occlusions.

To address this issue, we developed ChromoCloth, a soft and portable light source for photochromic objects that allows the user to reprogram the color of an object by wrapping the light source directly around the object. We accomplish this by ironing 3D printed diffusive housing onto a piece of velvet textile substrate, and weaving a flexible LED strip through the housings. Since the photochromic dye saturates with UV light and desaturates with specific wavelengths of RGB light, we provide two different ChromoCloths, each weaved with UV LED strip for the color saturation and with RGB LED strip for desaturation. Users can change the color of a photochromic object by wrapping the object first with UV ChromoCloth to achieve the saturated color, and then with RGB ChromoCloth to desaturate to the target color (Figure 1).

In summary, we contribute:

- a fabrication method to create a flexible light source with wavelength compatible with photochromic ink;
- housing structure to diffuse the light from the point-based LEDs from the LED strips to achieve even color on each pixel;
- an application that shows how ChromoCloth reprograms the surface texture of a mug.

2 CHROMOCLOTH

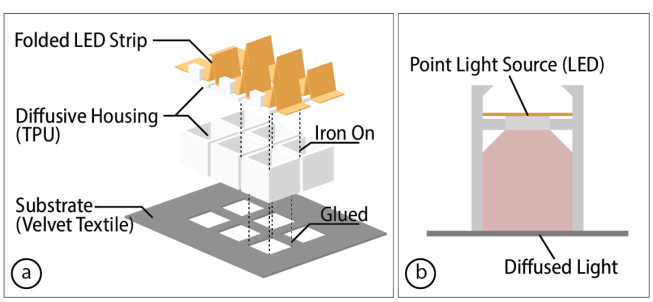

Figure 2: Structure of ChromoCloth: (a) ChromoCloth consists of the textile subtrate, the diffusive housing and the folded LED strip; (b) each diffusive housing block diffuses the point light source from an LED to be more uniform in a square area.

2.1 ChromoCloth Structure

The ChromoCloth consists of three parts: (1) a textile substrate with laser-cut square holes that holds the flexible structure together; (2) a set of diffusive housing 3D printed with TPU (thermoplastic polyurethane); (3) an LED strip weaved through the structure (Figure 2a).

To fabricate ChromoCloth, we first laser cut the velvet textile with square holes of 10mm by 10mm that are 13mm apart. The holes will become the color pixels that the ChromoCloth can reprogram. We then 3D print an array of 10 by 10 diffusive housing blocks with white TPU 95A (Printer Model: Ultimaker 3) at brim setting, which diffuses the point light source from the LEDs to be uniform in one pixel (Figure 2b).

Each housing block contains two separately 3D printed parts: the bottom vertical square tube and the LED clip. We bind the bottom part to the textile substrate by attaching them with a glue stick and then heating them to 140°C on a hot plate. We attach the top part to each LED on the LED strip by clipping them in place. We then bring the structure together by heat binding the two parts of each housing block with a soldering iron at 280°C. The distance between the two neighboring LEDs are longer than the distance between the centers of two neighboring pixels, allowing us to fold the excessive strip for flexibility along the strip.

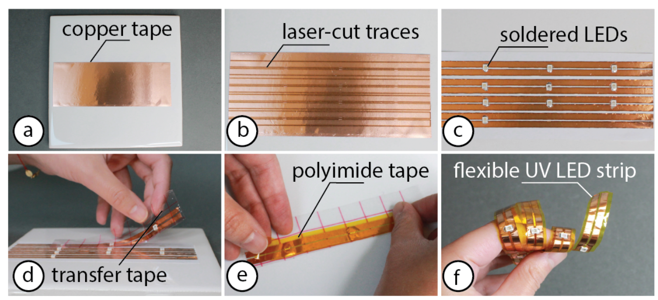

Figure 3: Fabrication process of custom UV LED strip with fiber laser cutting.

2.2 Custom UV LED Strip

The photochromic pigment used in this demo requires UV light source of wavelength less than 370nm to fully saturate. To achieve the optimal flexibility at this wavelength, we opt to fabricate our custom UV LED strip using a fiber laser cutter.

We first glue the copper tape onto a ceramic tile without peeling its paper substrate (Figure 3a). We then laser cut the edge of the trace pattern using a fiber laser cutter (model: MFP-B60). Once the lasing process is done, we peel off the tape in the non-conductive area and solder the UV LEDs (part number: WL-SUTW, peak wavelength: 365nm) with solder paste on a hot plate at 220°C (Figure 3bc).

To maintain the structure of the traces during subsequent handling, we secure it with polyimide tape on its back. To achieve this, we first use vinyl transfer tape to lift the traces and then place the polyimide tape manually on the back (Figure 3de). Because of the constraint from the size of the laser cutter, we cut multiple short strips of up to 3 LEDs and connect them into a longer strip of 10 LED (Figure 3f).

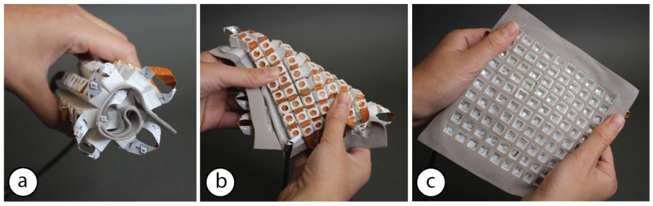

Figure 4: The ChromoCloth is flexible convex to the textile substrate, supporting interactions such as (a) rolling, (b) folding and (c) laying flat.

2.3 Flexibility

The ChromoCloth is flexible convex to the textile substrate, i.e. it allows folding inwards though not outwards. Figure 4ab shows that the ChromoCloth can be rolled and folded, allowing it to conform to the geometry of objects with high surface curvature. On the other hand, ChromoCloth allows bending only slightly in the other direction (Figure 4c), making it challenging to cover objects with concave surface structures.

3 APPLICATION

We demonstrate the functionality of the ChromoCloth by using it to customize the pattern on a mug (Figure 1) spray coated with photochromic paint. In the example, we first cover the object with UV ChromoCloth, a ChromoCloth made with a UV LED strip, and allow the mug's color to saturate in 3 minutes. We then cover the mug with the LED ChromoCloth for another 3 minutes, desaturating the color to show a stripe pattern. This allows one to reprogram the color of a daily object to show relevant information such as the date, and patterns such as pixel art.

4 CONCLUSION

We presented a method that allows user to reprogram the color of a photochromic object by wrapping it directly with a flexible and portable light source. Without the need to the turntable and projector setup, ChromoCloth allows for reprogramming the color without much disruption on the surroundings and on larger objects. We made the ChromoCloth by ironing the 3D printing diffusion housing on top of a textile substrate and weaving a flexible LED strip through the housings to program each pixel independently. Currently, the UV and RGB light sources are fabricated separately, but we envision an implementation where the UV and RGB lights are integrated.

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