# Photochromic Carpet: Playful Floor Canvas with Color-Changing Footprints

Daniel Saakes[1], Takahiro Tsujii[1], Kohei Nishimura[2], Tomoko Hashida[3], and Takeshi Naemura[1,2]

[1] Graduate School of Information Science and Technology, The University of Tokyo
[2] Graduate School of Interdisciplinary Information Studies, The University of Tokyo
[3] The Department of Intermedia Art and Science, Waseda University
{daniel,tsujii,nishimura,hashida,naemura}@nae-lab.org

**Abstract.** Natural environments record their past and reveal usage in subtle cues such as erosion and footprints. In modern society of concrete cities and dynamic touch screens, this richness is lost.

We present a large size interactive floor display that captures visitors' footsteps in playful prints to make a modern environment into a canvas of past activities. The implementation consists of a carpet coated with color changing ink and shoes that activate color changes. Each step a visitor makes results in a dynamic print that slowly fades away.

**Keywords:** color changing material, interactive floor display.

## 1 Introduction

In the classic fairy tale, Hansel and Gretel safely return home by tracing back their path using a trail of pebbles. Natural environments capture history in various ways from valleys carved out by rivers to the broken twigs that trackers use to locate animals. Man-made products depict their most frequent used functionally in wear, such as chipped off paint or the greasiness of buttons. However, in modern society of concrete buildings and dynamic touchscreen interfaces, these environmental clues of use are lost. With the photochromic carpet, we aim to re-introduce the concept of subtle recording of history in the environment and visualize patterns-of-use that interact with the user in a ludic way.

The system consists of a large floor painted with passive, mono-stable color changing ink that is excited by footsteps of custom indoor shoes with build-in LEDs. Wearing the shoes, users leave trails of dynamic generated patterns. The patterns persist for minutes and invite users to use the carpet as an expressive canvas. Using smart materials in the floor, and the shoe as an activation medium, the system easily scales to very large surfaces, without the limitation of installing a camera-projector system or sensor networks.

Our current demonstration serves no other purpose than an experiential prototype. Through exhibits we aim to gather user feedback for future applications in schools and hospitals.

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**Fig. 1.** The carpet is made from photochromic material that temporarily becomes dark purple under UV radiation. As shown, near UV LED embedded in shoes activate the color change long enough to create playful patterns.

## 2 Related Work

Our effort spans two different research areas: projects that aim to enrich human interaction with physical objects and projects that augment shoes and floors for sports, entertainment and as user interface.

The History Table Cloth by Gaver et.al. [2] consists of a table top embedded with electroluminescent material. The table senses objects placed on the table and lights up around the objects for hours visualizing the flow of objects. They so investigate digital technologies that aim to engage their users in playful open-ended interactions rather than functional. Like wise, in "Material Traces" Rosner et.al. [7] discuss the practice of materiality and implications for HCI, illustrated by a number of provocative ideas, such as paint that traces rodent movement in the house. These projects relate to our aim, but ideas are prototyped on objects. In contrast, the technology proposed in this demonstration makes these concepts experiential on large scale environments and includes a practical way of realization. In computer entertainment interactive floors are made popular with dance dance revolution [4] in which a floor functions as a input device for a dancing game. Various interactive floors have been proposed. For instance, the magic floor [5] aims to capture user motion, however require complex sensor networks. Other projects take reverse approach by embedding the sensor technology in the shoe rather than environment. Expressive footware [6] embeds sensors in various ways to capture sport and dance performance.

An early example of a floor as input and output medium is the artwork Boundary Functions by Scott Snibbe [9]. Using a webcam and projector setup, visitor activity is captured and graphics are projected accordingly. To address the limitations of resolution and occlusion, the multitoe floor [1] aims to build a floor with multitouch displays. In that way they explore various interaction techniques activated by feet rather than by fingers. However, current display and projector technologies have various shortcomings when applying for large surface, high resolution or daylight applications. Using mono-stable color changing materials solves these issues by exploiting the persistence of image as a physical frame buffer. In that way, no digital representation is involved in the process of

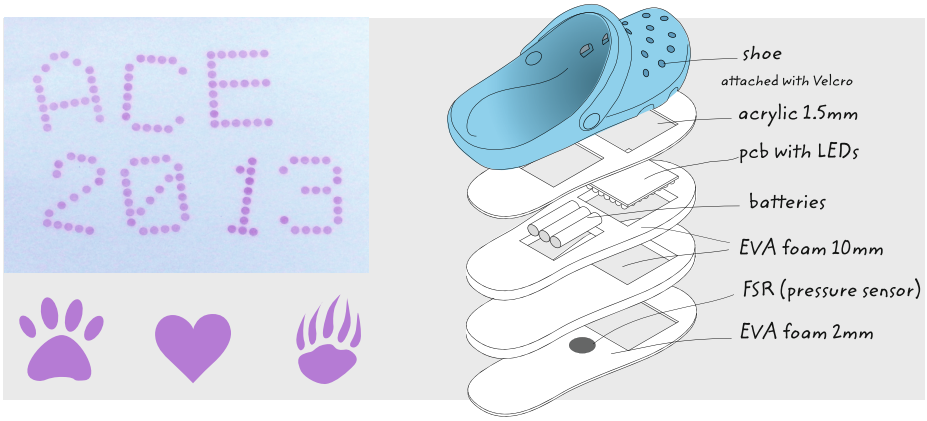


**Fig. 2.** The indoor shoes have custom soles attached with Velcro. The soles have an embedded LED array, and contain an accelerometer and pressure sensor for activation. Dynamic and static patterns are shown on the left.

capturing and displaying content. Because the photochromic carpet consists of a large area, sparsely populated with footprints, we can use the human as an actuator by embedding the color change activation mechanism in the shoe.

## 3 Design and Implementation

Various techniques are suitable for color changing floors to be used under daylight conditions [3,8]. Liquid floors react to pressure in interesting ways, but have only limited resolution. Thermochromic materials change with temperature, however activation technology is difficult to achieve in a small form factor. Therefore we‘ve selected the photochromic material Spiropyran that is activated with near UV radiation.

Spiropyran produces color under UV light and returns gradually to colorless and transparent when the UV light is blocked. For the prototype we selected deep purple because of its high contrast color change. Shown in Figure 1. , the prototype floor spans 3x3m$^2$ and is made out of 9 tiles. Each tile consists of a sandwich of the Spiropyran ink protected in 2mm acrylic sheet that is transparent for UV wavelengths.

The activation mechanism consists of a LED array embedded in the sole of shoes, as shown in Figure 2. The LEDs (Nichia NSPU510CS) have a peak wavelength of 375nm and in our setup an irradiance value of 4.642 $\mu$W/cm$^2$. For static patterns we use a 14 LED array, the dynamic pattern consists of a 64 LED array, driven by a constant current display driver that duty cycles the LEDs. We tuned the radiation duration to a maximum of 0.5 second per step, so that the color change in the floor that is persistent for approximately 5 minutes, depending on lighting conditions. The shoe sole is powered by three rechargeable aaa batteries. In practice, the batteries last for a few hours of use.

Because UV radiation is not safe for skin and eye contact, each shoe includes a safety mechanism driven by an Arduino. A FSR (Force Sensitive Resistor) detects whether shoe is pressed against a surface, and the accelerometer detects if the shoe is flat on the floor and without user induced acceleration. These two conditions have to be met in order to turn on the LEDs.

## 4 Future Work and Conclusion

In this project, human motion activates color changes that are spatially captured to make floors into a creative canvas that captures history. The system is implemented in the Miraikan National Museum of Emerging Science and Innovation in Tokyo and the exhibition will run for six months. Early feedback indicates that the system is popular by all ages.

Future versions could include wireless communication between all the shoes to coordinate dynamic patterns. In addition to shoes, other activation mechanisms could be explored such as autonomous or rc-vehicles.

Another avenue of research is to generalize the system for data visualization to represent transient data of the time domain, spatially on floors or walls.

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