# Polka Dot – The Garden of Water Spirits

Yohei KOJIMA* Yuichi ITOH* Taku FUJIMOTO*
Kazuma AOYAMA* Kazuyuki FUJITA* Kosuke NAKAJIMA*
Graduate School of Information Science and Technology, Osaka University

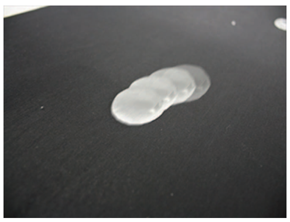

**Fig. 1** Polka Dot

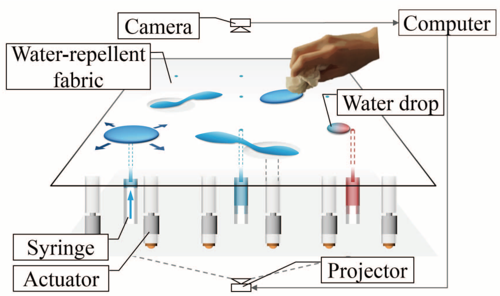


**Fig. 2** System Overview

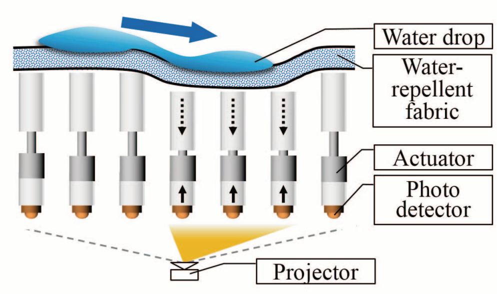


**Fig. 3** The Mechanism for controlling the position of the water drops

## 1. Introduction

Physical and tangible representations of information have provided users with intuitive interactions in which users can control information through tangible controls using their hands. In these techniques, flexible materials have often been utilized. For example, clay has been used for an intuitive modeling tool which senses the shape of the clay and updates its 3D model data [Piper et al. 2002]. This example enables users to create 3D models without knowledge of computational methods for constructing 3D models. Though these tangible representations of information accept user input, they cannot provide bi-directional physical interactions since their physical properties are not controlled by computers. Therefore, it is difficult to represent dynamic changes of information using physical properties such as motion, size, and color. These tangible user interfaces employ static materials.

Thus, we focus on water as a more flexible material that can easily change position, motion, shape, size, and color. We propose a fabric tabletop display called Polka Dot, which can control various properties of water drops on its surface.

## 2. Polka Dot

Polka Dot controls the properties of water drops including their position, motion, shape, size, and color. The system can represent dynamic changes of information and expand interaction.

Figure 2 shows the system overview. The system consists of a large piece of water-repellent fabric, an array of actuators, syringes, and a projector, camera, and computer. Fabric composes the surface of this system. An array of actuators and corresponding power supply lines are set under the fabric. The projector is connected to the computer and put behind the actuators and the camera is fixed in a location that looks down on the surface of the fabric.

To display the changing of position and motion of the water drops on the fabric, the system adjusts the unevenness of the fabric using actuators. Figure 3 shows the mechanism that moves the water drops. Since the water drops on the water-repellent fabric easily slide to the lower area by gravity, the system can move the water drops by pushing and pulling the fabric and changing the height using an underlying array of actuators. To control many actuators without delay and to keep a simple configuration even when enlarging the system, we employ simple optical communication between the computer and each actuator using the projector under the actuators. Each actuator is equipped with an optical sensor and a microcontroller. When the projector lights the actuator, the actuator pulls the fabric down. Then the area around the lighted actuator becomes concave. On the other hand, the actuator that is not lighted pushes the fabric up. Thus, all actuators communicate with the computer individually and simultaneously. This mechanism makes the system scalable.

The size of the water drops can also be changed by injecting (or extracting) the water on the fabric using a syringe with a thin needle stuck to the fabric from the back side. Small holes caused by the needles do not interfere with the water-repellent property of the fabric.

Additionally, the system adds color to the water drops by injecting colored water using the syringes or putting water-soluble paint on the fabric. These novel characteristics expand methods for expression in the physical world and open up the rich channel of communication between the user and computer.

## 3. Prototype

We investigated the minimum size of water drops able to be controlled by this configuration. We measured the minimum angles of water-repellent fabric to make water drops slide by gravity. We put various sizes of water drops (3.0 mm, 5.0 mm, 10 mm, and 15 mm in diameter) on a rigid plate covered with water-repellent fabric. While we tilted the plate slowly, we measured the minimum angle where the drops began to slide. As a result, the minimum angle for each water drop was 17, 6.1, 4.1, or 2.7 degree in order. The prototype actuators that push 10 mm up and are arranged 50 mm apart can make a slope at $\mathrm{Tan}^{-1}(0.2) = 11.3$ degree. Since 11.3-degree angle is bigger than the minimum angle for 5.0-mm diameter drops and smaller than that for 3.0-mm diameter drops, the prototype can control 5-mm diameter water drops. Furthermore, the same configuration has a potential to move smaller size of water drops when using smaller actuators and denser arrangement of them. This improvement enables richer physical expressions of information.

*e-mail: tamasui@hi-mail.ise.eng.osaka-u.ac.jp

## References

PIPER B., RATTI C., AND ISHII H. 2002. Illuminating Clay: A 3-D Tangible Interface for Landscape Analysis. *in Proc. of CHI '02*. pp. 355-362.


SIGGRAPH 2013, July 21 – 25, 2013, Anaheim, California.

ACM 978-1-4503-2261-4/13/07