Ficon: a Touch-capable Tangible 3D Display using Optical Fiber

Yuta Takada
Meiji University
1-1-1 Higashimita, Tama-ku
Kawasaki-shi Kanagawa
2314578 JAPAN

Ryusuke Nakabayashi
Meiji University
1-1-1 Higashimita, Tama-ku
Kawasaki-shi Kanagawa
2314578 JAPAN

Kentaro Fukuchi
Meiji University
1-1-1 Higashimita, Tama-ku
Kawasaki-shi Kanagawa
2314578 JAPAN
kentaro@fukuchi.org

Abstract
We present a touch-capable 3D displaying device for tabletop systems called a Ficon. A Ficon has a 2.5-dimensional shape for providing tangible dynamic 3D visual. While most tangible devices for tabletops display their associating information around themselves, a Ficon displays such information on its top touch-capable surface. A Ficon consists of a bundle of optical fibers with a polished flat bottom surface. When a Ficon is placed on the surface of a tabletop system, the light from the bottom surface is conducted to the top surface through the optical fibers, allowing the system to control the visuals of the Ficon by displaying images at its position. Two methods for constructing a free-form 3D display using a Ficon are introduced: the use of a CNC milling machine to create a pre-shaped Ficon from a 3D model, and a building-block approach using a set of primitive Ficons.

Author Keywords
Tabletop interface; tangible UI; 3D display.

ACM Classification Keywords
H.5.2. [User Interfaces]: Input devices and strategies

General Terms
Human Factors; Design.

Introduction

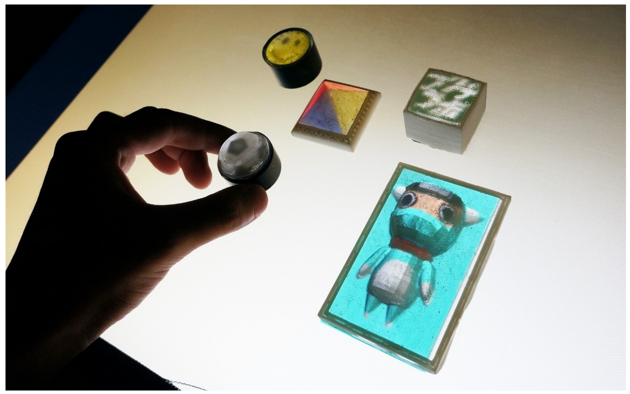

Figure 1: Ficon examples. A Ficon manufactured using a machine milling from a 3D model, and primitive shaped Ficons such as a pyramid, cylinder, cube, and hemisphere.

An interactive tabletop system mostly employs tangible input devices, with a touch-capable table as its interface. Tangible devices that have a specific appearance associated with a logical object or function are referred to as physical icons or "phicons"[5]. The benefit of a phicon is its intuitiveness and tangibility. The user can easily find an appropriate device to manipulate the target object intuitively.

Like typical objects, the appearance of a phicon is static. This static appearance is the basis of a phicon's intuitiveness. On the other hand, thanks to the developments in touch-sensing technology and large-sized displays, recent tabletop systems have employed high-resolution, multi-touch capable displaying surfaces that can provide dynamic and interactive visuals, which has brought to light the lack of a dynamic appearance or high interactivity of phicons. Detailed information associated with an input device on a tabletop is often displayed around the device itself, and detailed interactions with the device are performed using the table's touch sensor. The users have to take their eyes away from the device, breaking the feeling of direct manipulation[4]: in addition, the surrounding information and GUI occlude other information from being displayed on the table.

To solve these issues, we introduce a new tangible input device called a "Ficon" that allows dynamic information to be displayed on its top surface and recognizes touch interaction[2]. A Ficon consists of a bundle of optical fibers, and its bottom surface is flat and polished. The fiber conducts light from one end of the fibers to the other, allowing the bundle of the fibers to display an image projected onto the bottom surface of the Ficon on the top surface, similar to a fiberscope or ulexite (also known as a "TV rock"). By using these optical fiber characteristics, a Ficon can also change its appearance when placed on a display without any occlusion problems. It does not require the surrounding display space to show associated information about the Ficon. Its top surface is also not limited to a flat shape, and can provide a 2.5D curved surface to provide 3D visuals, as shown in Figure 1. Unlike stereoscopic 3D displays, it does not require a viewer, and can provide natural parallax. While the previous implementation of Ficons had occlusion and touch capability problems[2], we have introduced a diffused-illumination based implementation to solve these issues.

Implementation

Figure 2 shows an illustrated overview of the proposed system. Ficons are manipulated on a tabletops system employing a diffused-illumination (DI) technique[3]. We employed a Touchlib for touch detection, allowing the user to perform basic touch-based interactions on the table. Touchlib is also used to track the Ficons.

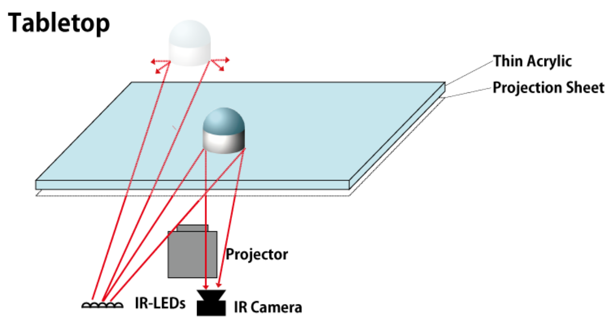

Figure 2: Illustrated overview of the tabletop system and a Ficon.

Ficon

A Ficon consists of a bundle of optical fibers and a frame. We used plastic IR-conducting optical fiber as the raw material instead of glass fiber, as the former is easier to manipulate using normal tools (including a milling machine). To prepare for the milling process, the fiber bundles are tightly bound by an epoxy adhesive.

The bottom surface of a Ficon is flat and polished to reduce light loss. The top surface is shaped by a computer-controlled milling machine (Roland's Model MDX-40), enabling the use of a 3D model (Figure 4).

The bottom surface of the Ficon frame is painted black to avoid reflection, and 5mm×5mm IR reflection markers are placed onto the bottom surface of the frame. For this reason, the thickness of the frame must be wider than the size of the markers. The position, orientation and ID of a Ficon are recognized from the pattern of its markers. The current implementation provides a limited set of IDs for simplification: however, the number of sets can be increased by introducing a barcode-like encoding system.

Touch Detection

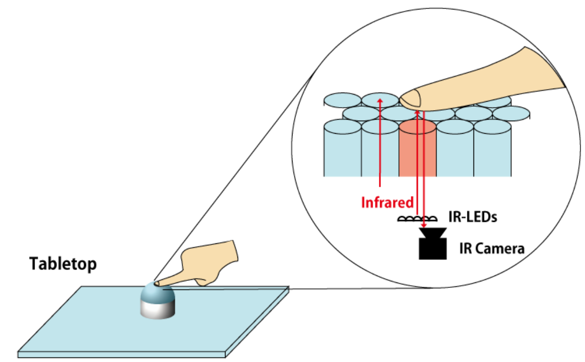

Figure 3: Touch detection process: the light from the IR LEDs is conducted to the top surface of the Ficon, and is then reflected by the user's fingertip, and conducted back to the tabletop surface.

Figure 3 illustrates the mechanism of touch detection on a Ficon. Similar to a DI table, the touch detection is performed by observing the light reflection from the fingertip. The fibers conduct the IR light from the diffusing layer of the tabletop surface to the top surface of the Ficon. When a fingertip is placed just above the surface, the reflected light is conducted by the fiber again, and is then observed by the IR camera and recognized by the Touchlib. When a new fingertip is found within the area of the Ficon, the system calculates the relative position of the fingertip and handles it as a touch on the Ficon. The system is multi-touch capable within the Ficon size restriction.

The precision of the recognized position is not as high as the touch on the tabletop surface owing to light loss at both ends of the fiber bundle. The current prototype therefore requires a large number of IR LEDs than a usual DI-based table for robust touch detection.

3D representation

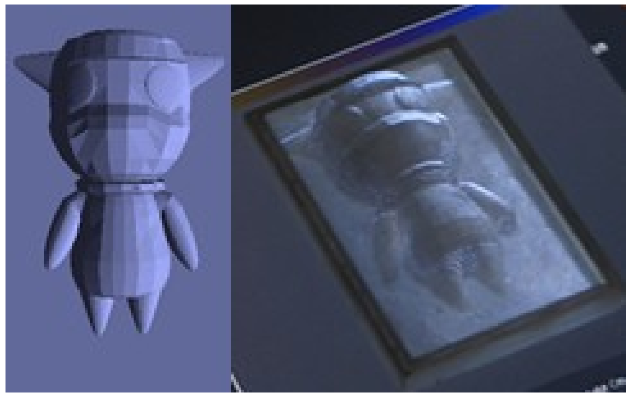

Figure 4: 3D model of a Ninja character and a Ficon. A shaded image of the same model is displayed on the Ficon.

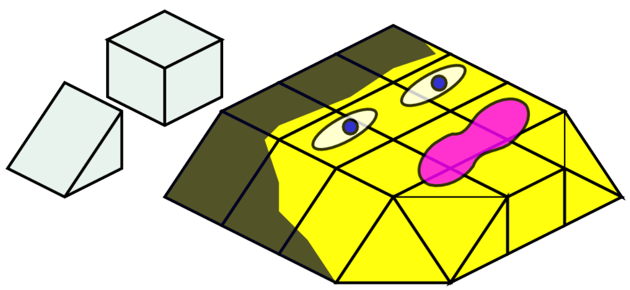

Figure 5: Ficon-based building blocks used to construct a 3D shape.

Ficon enables a dynamic touch-capable 3D image to be created from an existing 3D model. Figure 4 shows a sample of a 3D-shaped Ficon generated from a 3D model of a Ninja character. By displaying a shaded image rendered from the same 3D model, the Ficon appears to be illuminated. A Ficon can also display dynamic animation with the exception of changes in posture or shape. Owing to this limitation, the display is best suited for small motions such as lip syncing, blinking, blushing, and eye gazing.

Figure 5 illustrates another idea for a deformable 3D display: a set of primitive Ficon buidling blocks. This system tracks the Ficons on the table and estimates their connections. While Ficon cannot be stacked, unlike in Lumino[1], various shapes including diagonal cuts can be created.

Acknowledgements
This work was supported by JSPS KAKENHI Grant Number 23700090.

References

[1] Baudisch, P., Becker, T., and Rudeck, F. Lumino: tangible blocks for tabletop computers based on glass fiber bundles. In *Proceedings of CHI '10*, ACM (2010), 1165–1174.

[2] Fukuchi, K., Nakabayashi, R., Sato, T., and Takada, Y. Ficon: a tangible display device for tabletop system using optical fiber. In *Proceedings of ITS 2011*, ACM (2011).

[3] Matsushita, N., and Rekimoto, J. Holowall: Designing a finger, hand, body, and object sensitive wall. In *Proceedings of UIST '97* (1997), 209–210.

[4] Shneiderman, B. Direct manipulation: A step beyond programming languages. *IEEE Computer 1983*, 16 (1983), 57–69.

[5] Ullmer, B., and Ishii, H. The metaDESK: Models and prototypes for tangible user interfaces. In *Proceedings of UIST '97* (1997), 223–232.