ForceTile: Tabletop Tangible Interface with Vision-based Force Distribution Sensing

Yasuaki Kakehi* Kensei Jo† Katsunori Sato† Kouta Minamizawa†
Hideaki Nii† Naoki Kawakami† Takeshi Naemura† Susumu Tachi†
*Presto, Japan Science and Technology Agency †The University of Tokyo

Figure 1: Photo Viewer with ForceTiles

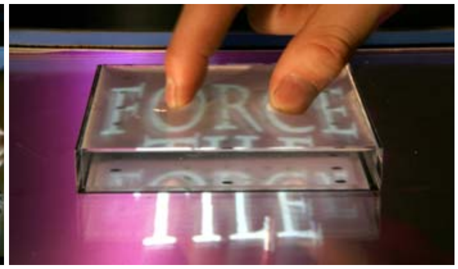

Figure 2: Pinching/stretching interaction

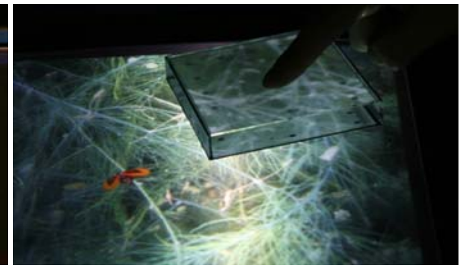

Figure 3: Interaction with force vectors

1 Introduction

Today, placing physical objects on a tabletop display is common for intuitive tangible input [Ullmer and Ishii 1997]. The overall goal of our project is to increase the interactivity of tabletop tangible interfaces. To achieve this goal, we propose a novel tabletop tangible interface named 'ForceTile.' This interface can detect the force distribution on its surface as well as its position, rotation and ID by using a vision-based approach. In our previous optical force sensors "GelForce" [Kamiyama et al. 2004], an elastic body and cameras are fixed together. Contrarily, on this system, users can place and move multiple tile-shaped interfaces on the tabletop display freely. Furthermore, users can interact with projected images on the tabletop screen by moving, pushing or pinching the ForceTiles.

2 Technical Innovations of ForceTile

In our ForceTile, we offer core technical innovations as following.

One is the design of the interface and the table-based camera system to detect the force distributions of each tiles on the tabletop. The tile interface consists of a transparent acrylic case filled with an elastic body, two layers of markers attached within the body for the force distribution sensing and a marker attached underneath the case for the position sensing. Inside the table, cameras and IR light emitters are installed underneath. When users put ForceTiles on the tabletop, the system detects their locations and ID by the shape of position marker. Furthermore, to calculate the force vectors on the surface, we adopt the method of GelForce. When forces are applied on the surface of the ForceTile, this system derives the force vectors by detecting the internal strain of the body through the movement of the force markers. Note that no electric devices are attached on the tabletop interfaces and users need not wear any special equipment for interaction.

Secondly, this system can show images on the tabletop screen and ForceTile surfaces. By making a force marker with a transparent heat insulating material that passes the visible incoming light and blocks the infrared incoming light, this system can adopt a back projection so that the interface bodies and user's hands don't disturb the projection light.

Third innovation is a software architecture design for recognizing users' actions and generating projection images. According to various input information such as position, rotation, ID of tiles, intensity and direction of forces applied on them, users can control projected images in real-time.

3 Applications

While ForceTile offers brand new interactions on tabletop, it can integrate several functions of previous interfaces simultaneously such as touch panel, pointing device (i.e. mouse), tangible physical interface and small-sized screen. We have already implemented some interactive applications.

One is photo viewer application (see Figure 1). Initially photo images are displayed on the tabletop. By pushing the ForceTiles, you can change the displayed photo or the image size. In the second application, you can control the tabletop image with multiple fingers. When you pinch or stretch the tile's surface, the scale of the tabletop image changes according to the intensity and the direction of the force (see Figure 2). The third application is for entertainment. On the tabletop screen, an image of a lady beetle is walking around. When you cover the ForceTile on the lady beetle and apply a force on it, it flys away according to the magnitude and direction of the applied force as Figure 3. In the future, we plan to develop much more applications by using the ForceTiles in various situations.

References

KAMIYAMA, K., KAJIMOTO, H., KAWAKAMI, N., MIZOTA, T., TACHI, S., AND VLACK, K. 2004. GelForce. In *SIGGRAPH Emerging Technologies*, ACM.

ULLMER, B., AND ISHII, H. 1997. The metadesk: Models and Prototypes for Tangible User Interfaces. In *Proceedings of UIST'97*, ACM, 223–232.

*e-mail: tabletop@hc.ic.i.u-tokyo.ac.jp

SIGGRAPH 2008, Los Angeles, California, August 11–15, 2008.
ISBN 978-1-60558-466-9/08/0008