Flip-Flop Sticker: Force-to-Motion Type 3DoF Input Device for Capacitive Touch Surface

Kaori Ikematsu
Ochanomizu University
Tokyo, Japan
ikematsu.kaori@is.ocha.ac.jp

Masaaki Fukumoto
Microsoft Research
Beijing, China
fukumoto@microsoft.com

Itiro Siio
Ochanomizu University
Tokyo, Japan
siio@acm.org

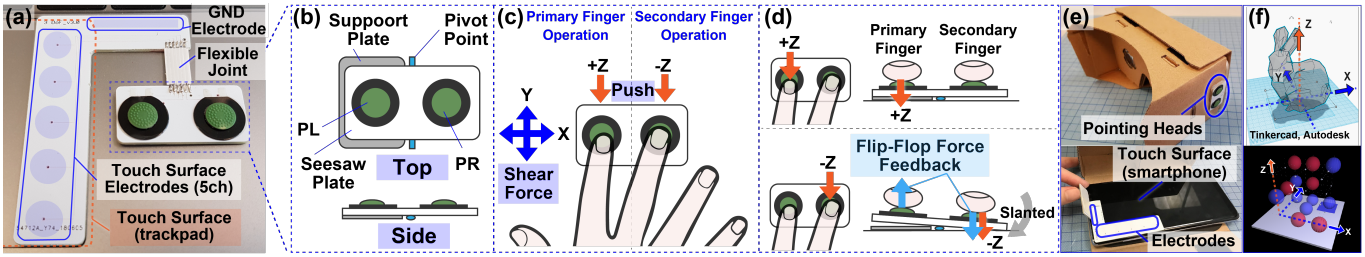

Figure 1. (a) Flip-Flop Sticker attached to the trackpad; (b) The structure of Flip-Flop Sticker; (c) Applying shear force (sliding to any optional direction) to PL is assigned as X/Y-axis operations and applying pressure force (pushing down) to PL/PR is assigned as Z-axis (+Z/-Z) operations; (d) The seesaw-like mechanism enabling "upward" force feedback to a primary operation finger; (e) Flip-Flop Sticker can also be utilized as a head-mounted display adapter; (f) Applications : 3D (X/Y/Z) operation in 3D CAD and 3D Tic-Tac-Toe can be realized by orthogonal and intuitive operation.

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3DoF Operations; Input Device; Force-to-Motion.

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INTRODUCTION
Recently, operations used in 3D environments have been gradually increased. However, existing input devices for 3DoF or 6DoF operations have potential issues. The first issue is lack of intuitiveness. Some devices have a special button or dial enabling Z-axis operations [1]. These types of Z-axis operations are not orthogonal compared with X/Y-axis operations, and not very intuitive. The second is an increase in a user's fatigue. Some devices assigning push or pull movement with the pointing head for Z-axis operations [2] are intuitive, however, pulling action may increase fatigue. To solve the above-mentioned problems, we propose Flip-Flop Sticker, a novel force-to-motion type input device enabling 3DoF operations. This device provides users with a "flip-flop" movement so that they can easily distinguish between +Z and -Z operations.

FLIP-FLOP STICKER
Figure 1 (a–d) shows the structure of Flip-Flop Sticker. Flip-Flop Sticker provides force-sensitive inputs similar to the pointing stick (TrackPoint [2]). It has two circular pointing heads (PL and PR), PL is operated by a primary (index) finger for X/Y-axis and Z-axis (+Z) operations while PR is operated by a secondary (middle) finger for Z-axis (-Z) operations. At the bottom of the device, a seesaw-like mechanism that switches up and down movement around a pivot point is attached. When pressure force is applied to PL, a support plate retains the seesaw plate horizontal. On the other hand, when pressure force is applied to PR, the seesaw plate is slanted around the pivot point. The small seesaw movements generate flip-flop (upward or downward) movements toward the pointing heads. Therefore, the upward force feedback is applied to the primary finger and provides the user with a mental image of a stepping-up motion. Generally speaking, any kinds of raising actions against gravity may cause fatigue. Our proposed structure provides upward motion without manually raising a finger. In addition, the Z-axis motions (+Z and -Z) are orthogonal. Therefore, Flip-Flop Sticker realizes both low fatigue and intuitive Z-axis operations.

Flip-Flop Sticker was implemented based on Ohmic-Touch [1] technology, that is, detecting change in resistance value by using a capacitive touch surface. Flip-Flop Sticker has 5-channels force sensors implemented by force-sensitive-resistor (FSR) films and comb electrodes on a printed circuit board. By using this, finger micromotions on PR/PL are transferred as the change in resistance value. Thus, by attaching Flip-Flop Sticker to a capacitive touch surface, force-to-motion input can be provided. For the seesaw-like mechanism, a loosely creased PET film was used for the pivot point to increase durability and also stability when -Z force is not applied. The total thickness of Flip-Flop Sticker is less than 2.0 mm, thus, it is suitable to attach to modern laptop PCs, smartphones or HMD equipped with a capacitive touch surface (see Fig.1 (e)).

To demonstrate our proposed device, we implemented applications enabling 3D Tic-Tac-Toe and commercial 3D CAD to operate by using Flip-Flop Sticker (see Fig.1 (f)).

[1] 3D Pro Mouse (Lexip)
[2] SpaceMouse (3Dconnexion), Wing (Worthington Sharpe)

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