SlickFeel: Sliding and Clicking Haptic Feedback on a Touchscreen

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ABSTRACT

We present SlickFeel, a single haptic display setup that can deliver two distinct types of feedback to a finger on a touchscreen during typical operations of sliding and clicking. Sliding feedback enables the sliding finger to feel interactive objects on a touchscreen through variations in friction. Clicking feedback provides a key-click sensation for confirming a key or button click. Two scenarios have been developed to demonstrate the utility of the two haptic effects. In the first, simple button-click scenario, a user feels the positions of four buttons on a touchscreen by sliding a finger over them and feels a simulated key-click signal by pressing on any of the buttons. In the second scenario, the advantage of haptic feedback is demonstrated in a haptically-enhanced thumb-typing scenario. A user enters text on a touchscreen with two thumbs without having to monitor the thumbs' locations on the screen. By integrating SlickFeel with a Kindle Fire tablet, we show that it can be used with existing mobile touchscreen devices.

ACM Classification: H.5.2 [Information interfaces and presentation]: User Interfaces. - Graphical user interfaces.

Keywords: Haptic display; clicking feedback; sliding feedback, touchscreen

INTRODUCTION

As touchscreens become the dominant input method for mobile devices, there is a growing need for haptic feedback to alleviate the over-reliance on visual feedback for interacting with onscreen objects and for text entry on a touchscreen. Currently, when we slide a finger over an icon, we feel nothing. When we tap a finger on a button, the activation of a function is conveyed mainly through a change of the visual state. This lack of haptic feedback leads to the constant monitoring of the operation of a touchscreen through vision, causing the eyes to dart from one part of the screen to the other (while typing) or otherwise be glued to the screen. A common solution is to provide vibrotactile feedback when a key is pressed. We argue, however, that buzzing is inherently ambiguous and does not correspond to the sensations associated with rubbing a finger over a textured surface or tapping a finger on a mechanical key. In this demonstration, we present SlickFeel, a new haptic display that renders interactive objects on a touchscreen as textured patches and confirms a key press with a sensation that feels like a key click. Although prior work has shown haptic devices that display texture to a sliding finger *or* key-click like feedback to a tapping finger, this is the first time that the two types of haptic feedback have been combined into one display using piezo (short for piezoelectric) actuators. Compared with other haptic actuators (e.g., dual mode vibrotactile actuator), piezo actuators have the advantages of faster response time and wider bandwidth.

For sliding feedback, several haptic technologies are available to deliver information to a sliding finger through modulation of surface friction. With a force-feedback display, the variation in friction force can lead to a perception of surface texture [6]. The Tactile Pattern Display (TPaD) is capable of *reducing* the surface friction between the finger and a glass plate vibrated at an ultrasonic frequency using resonating piezo actuators [7]. The Stimtac system [1] provides programmable friction reduction with a similar mechanism. Electrovibration (also known as electrostatic effect) can *increase* the friction between a finger and a surface by modulating the electrostatic force between the two [5, 2]. For clicking feedback, several mobile devices (e.g., Motorola ROKR E8 and Blackberry Storm) used piezo actuators to deliver key-click signals. A recent study has shown that up to six distinct key-click feedback signals can be achieved with one piezo actuator [3]. Another study investigated the effect of delay and signal duration of key-click feedback using a 4-piezo keypad prototype [4].

IMPLEMENTATION

SlickFeel uses multiple piezo actuators to deliver sliding feedback [7] and clicking feedback [3] in one integrated system on a clear glass plate. The challenge is to ensure that the piezos for key-click simulation do not cross adjacent nodal lines generated by TPaD piezos. This was achieved by adjusting the actuation frequency of the TPaD piezos and the size/placement of key-click piezos. The haptic display (Fig. 1) consists of two identical units that are mechanically isolated to simultaneously render different haptic feedback to two fingers. Each haptic unit is composed of one 1.7 mm glass plate and two sets of piezos glued to the edges of the glass plate. TPaD piezos are activated at ≈ 30 kHz to cause the glass to resonate so that the friction between the finger and the glass can be modulated to create sliding feedback. Key-click piezos are activated with 3 cycles of a 500 Hz raised sinusoidal signal to generate clicking feedback. SlickFeel is attached to the 7" touchscreen of a Kindle Fire tablet computer. The tablet transfers finger position sensed by its

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touchscreen to a PC via WIFI. The PC processes the position information and sends the appropriate input signals by a USB cable to the SlickFeel driver board that generates, amplifies and controls the driving signals to the piezo actuators.

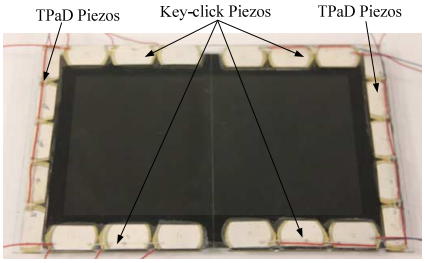

Figure 1. SlickFeel setup

DEMO SCENARIOS

Two demo scenarios have been developed for SlickFeel. The first is a simple demo that illustrates the different haptic sensations achievable with SlickFeel. As shown in Fig. 2, the screen shows four buttons: two buttons on the left rendered with a rough surface texture (higher friction) and two buttons on the right rendered with a smooth surface texture (lower friction). The clicking feedback for the buttons with a smaller travel distance (top two) is rendered with a smaller signal amplitude than that for the buttons with a larger travel distance (bottom two). This demo familiarizes users with the variety of sliding and clicking feedback signals that can be delivered with SlickFeel.

Figure 2. Button-click Interface

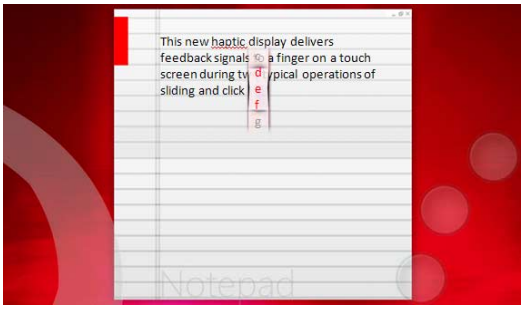

Figure 3.Thumb-typing interface

The second demo embeds the sliding and clicking haptic feedback in a thumb-typing scenario (Fig. 3) when the user is holding the tablet with both hands. The typing interface consists of two input areas in the left and right bottom corners of the touchscreen, and a letter selection ribbon that follows the text input cursor and highlights three contiguous letters in the English alphabet. The left thumb moves up and down along an arc (lower-left input area) to scroll the ribbon and change the group of letters being highlighted. The right thumb clicks on one of the three buttons in the lower-right input area to select the desired letter that corresponds to the button. The top, middle or bottom letter can be selected by clicking the top, middle or bottom button, respectively, by the right thumb. SlickFeel renders a rough texture on the arc and the buttons so they feel different from the smooth texture on the rest of the touchscreen. It also delivers a key-click feedback when a button is pressed by the right thumb. The haptic feedback allows the user to focus the visual attention solely on the document and the letter-selection ribbon instead of the input areas, as they can rely on the haptic feel to maintain their thumb positions on top of the relevant input controls. When no finger touch is detected by the touchscreen, the input controls are visualized translucently to guide the user's initial placement of their thumbs. They fade out after 3 s of continuous input to further avoid competing for visual attention. The haptically-enhanced thumb-typing interface eliminates the need to shift one's gaze back and forth between the document and a software keyboard as they would on today's touchscreens, and leverages the coordination between both thumbs in the common two-handed grasp of the tablet.

CONCLUSION

SlickFeel provides both sliding and clicking feedback on a touchscreen through a single hardware setup. Integrating it with a Kindle Fire tablet demonstrates that SlickFeel can be used with existing mobile touchscreen devices for enhanced user experience.

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