Surface Haptic Interactions with a TPad Tablet

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ABSTRACT
A TPad Tablet is a tablet computer with a variable friction touchscreen. It can create the perception of force, shape, and texture on a fingertip, enabling unique and novel haptic interactions on a flat touchscreen surface. We have created an affordable and easy to use variable friction device and have made it available through the open-hardware TPad Tablet Project. We present this device as a potential research platform as well as demonstrate two applications: remote touch communication and rapid haptic sketching.

Author Keywords
Surface Haptics, Touchscreen, Variable Friction, Tablet

ACM Classification Keywords
H.5.2. Information interfaces and presentation (I.7): User Interfaces (D.2.2, H.1.2, I.3.6): Haptic I/O

INTRODUCTION
A TPad Tablet is a handheld device (Figure 1) that is able to vary friction between a fingertip and the surface that it is touching. This enables a dynamic interaction where users can actively explore an environment and feel it respond to their touch. Different than vibration, the variable friction TPad (tactile pattern display) surface allows resistance forces to be applied against your finger. This means for example, that you can design a slider that pushes back against you and then releases as you unlock it, an icon that has shape, or a textured button that grabs the finger to confirm that it is currently selected.

THE TPAD TABLET PROJECT
This technology has been progressing in engineering research labs for many years [8, 5, 1], and initial user studies have shown a performance advantage as well as an increased sense of enjoyment, engagement, and realism [3, 4]. It is now to a point where it can serve as a platform for exploring questions about touch feedback user interfaces. To this end, we have launched an open-hardware initiative called the TPad Tablet Project. The goal of the TPad Tablet Project (http://tpadtablet.org) is to improve human interactions with computers and mobile devices through the sense of touch.

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THE TPAD FIRE
The TPad Fire is the first generation device of the TPad Tablet Project [6]. It is a hand-held device 200mm x 140mm x 43mm and 850g total. It is comprised of a TPad variable friction surface, a Kindle Fire™ tablet, a printed circuit board, a 6600 mAh battery, and a protective plastic case. It was designed to be affordable, easy to use, and widely available. The full device design and instructions for building and programming the device are available at http://tpadtablet.org, and are free for research and other non-commercial use. Example software code is also available through the website, as well as a growing community forum.

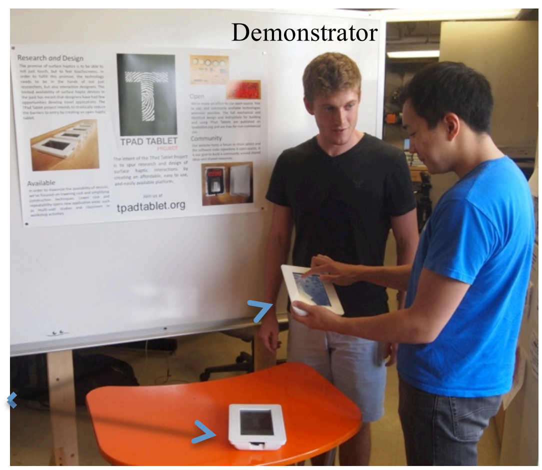

Figure 1: Demonstration Setup

Variable Friction Surface
The variable friction effect of the TPad is achieved through ultrasonic vibration of the touch surface. Watanabe and Fukui observed that ultrasonic vibration could reduce the coefficient of friction of sandpaper, Windfield et al. applied the same principle to glass, and Marchuk et al. expanded the usable area further to a 75x75 mm glass sheet [7, 8, 5].

The variable friction surface of the TPad Fire is built with a row of piezoelectric actuators attached to an even larger 165x130 mm sheet of glass. The actuators excite a standing wave resonance mode at 33.5kHz so that microscopically, the glass takes a sinusoidal shape. The zero crossings, called nodal lines, do not move at all, while the peaks travel up and down normal to the plane with an amplitude of up to 1.2µm. This motion gives rise to regular impacts which break contact between the glass and skin [2]. The coefficient of friction decreases proportionally with increased amplitude of motion [8, 2]. Because the frequency of motion is higher than can be perceived by humans, no feeling of vibration is felt, only the net reduction in friction force. While there is no motion at the nodal lines, they are spaced only 8mm apart. This is generally narrower than the finger pad, which spatially averages the friction force and renders the nodal lines barely noticeable.

Tablet

Integrating with a commercial tablet brings together many essential device functions into one low-cost package. The glass TPad surface is mounted directly to the tablet, and the tablet's capacitive touchscreen is used to sense finger position through the glass. All computation of friction level and graphics is done on the tablet's Java-based Android™ programming environment, which provides easy integration with tablet features such as audio output and Wi-Fi communication. Additionally, the open nature of the operating system allows for applications and code to be easily and quickly shared, modified, and installed.

DEMONSTRATION

We will provide a hands-on demonstration of three TPad Fire devices (Figure 1). Users will be able to hold the device and interact with our core set of demo applications which include a music player interface, a combination number input interface, and a bouncing ball collision application among others (more information and pictures on http://tpadtablet.org/home/demo/). Additionally, there are two interactive applications that we will demo publicly for the first time.

Application 1: Remote Touch

The first (Figure 2a) is a remote-touch app that attempts to tap into the personal and emotional aspects of the sense of touch. As one user places her finger on the screen, it is represented both visually and haptically on the other user's screen and vice versa, conveying a sense of presence and connection across distance.

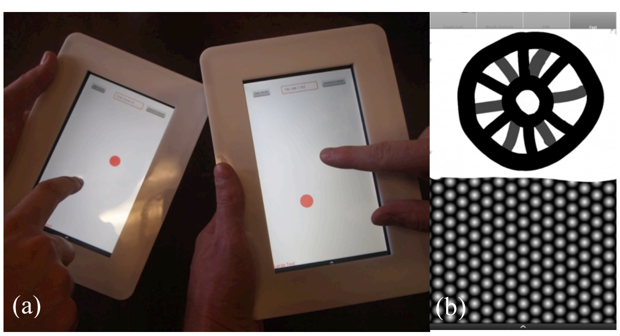

Figure 2: (a) Remote Touch App, (b) Haptic Canvas App showing a hand sketched haptic prototype with low friction (white) and high friction (black) areas.

Application 2: Haptic Canvas

The second is a haptic sketching app that attempts to lower the barrier of entry to designing haptic effects while also allowing rapid iteration of prototypes. With the app, a user can design a haptic effect without any programming. The user can draw directly on the screen with their finger and then immediately feel what they have drawn. The color value from black to white is interpreted as friction value from high to low. Additionally, a bitmap image can be loaded and displayed directly. This allows for more complicated and precise designs, and is especially well-suited for textures. Figure 2b shows a top area where a circular dial has been sketched by hand above a bump pattern that was loaded as an image.

CONCLUSION

The TPad Tablet Project presents variable friction surface haptic technology as a platform for user interface researchers and designers. The TPad Fire is affordable, available, and easy to use. Conference attendees will benefit from a hands-on demonstration of three TPad Fire devices, including apps that demonstrate remote touch communication and rapid haptic sketching.

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