ThickPad: A Hover-Tracking Touchpad for a Laptop

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ABSTRACT
We explored the use of a hover tracking touchpad in a laptop environment. In order to study the new experience, we implemented a prototype touchpad consisting of infrared LEDs and photo-transistors, which can track fingers as far as 10mm over the surface. We demonstrate here three major interaction techniques that would become possible when a hover-tracking touchpad meets a laptop.

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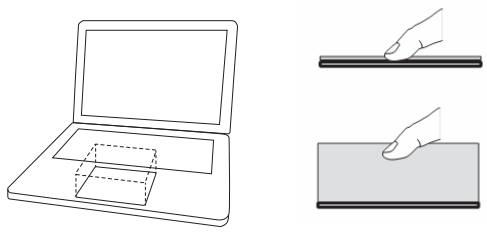
General terms: Design, Human Factors.

Keywords: Hover tracking touchpad, laptop touchpad, ThickPad.

INTRODUCTION
A touchpad is the most common pointing device for a laptop computer. A laptop touchpad however usually detects contacts only and cannot sense hovering fingers. We were interested in new interaction techniques that may become possible when a hover-tracking touchpad meets a laptop.

There has been a lot of research on a hover-tracking surface. SmartSkin [5] uses capacitive sensing to detect hands above the surface. This technology however is not applicable to a small touchpad because a hover-tracking range is reduced as the touch surface becomes smaller. TactaPad from Tactavia uses a camera to acquire the image of hands so that a user can see the movement of the hands on the screen before touching the touchpad. Visual Touchpad [4] used two cameras to acquire the stereo image of hands over the touchpad for both touch detection and hover tracking. However, camera-based methods are often too slow to provide an effective visual feedback. ThinSight [3] used an array of optical sensors behind an LCD to realize a thin, depth-sensing display. BiDi screen [2] also proposed a thin, depth-sensing LCD and investigated possible 3D interaction techniques with a prototype BiDi screen. Z-touch [6] uses a combination of a multi-layered infrared (IR) laser plane and a high-speed camera for depth-sensing. RemoteTouch [1] is a small touchpad for a TV remote, consisting of array of IR LEDs and photo transistors to get a thumb image over the touchpad. While other depth-sensing display technologies may be adapted for a laptop touchpad, RemoteTouch seemed to be most suitable for a laptop touchpad since its hover-tracking range is large enough and its structure is simple and thin.

We implemented a hover-tracking touchpad that we call ThickPad following RemoteTouch [1], and studied new interaction possibilities when sensing space is expanded into the space above the touchpad as shown in Figure 1a. With a ThickPad, we explored some novel interaction techniques which utilize the space above the touch surface.



(a) (b)

Figure 1: (a) The concept of ThickPad: new interaction space is added above the touchpad, and (b) we now have two different modes: fingers or a hand on or over the pad.

IMPLEMENTATION
As shown in Figure 2a and b, we made a hover tracking touchpad with the same size as a MacBook 13' touchpad. Similar to the optical touchpad in RemoteTouch [1], ThickPad consists of three layers: a press-sensing layer (a physical button), a touch-sensing layer (a transparent conductor), and a hover sensing layer (infrared LEDs and photo-transistors). Therefore, a ThickPad has four states (off, hover, touched, and pressed). The 8x10 LEDs illuminate sequentially in the row-major order. The 9x11 photo-transistors, all of which are wired in parallel and act as a single planar sensor, measure reflections from fingers or a hand. Figure 2c shows an image made of 8x10 sensor values. To obtain an interpolated hand image as shown in Figure 2d, we used the same signal processing steps in RemoteTouch [1].

After that, features of the image can be processed based on the purpose of its usage. For example, multiple fingertips are detected using simple thresholding. Also, we used template matching method to detect new gestures such as typing context gestures and area gestures. Finally, our demo application used modified multi-touch protocol (TUIO) in order to include new gesture set.

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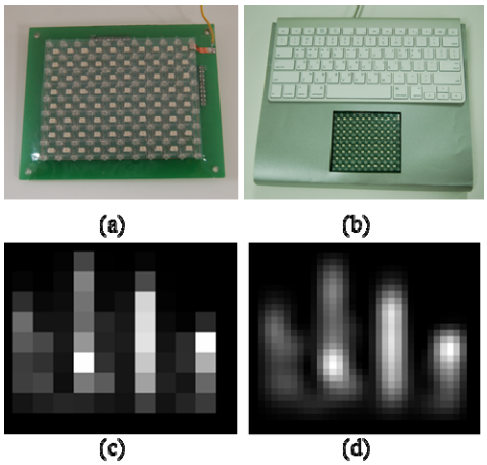

Figure 2: (a) ThickPad hardware, (b) ThickPad added to a laptop-like environment, (c) an 8x10 sensor image, and (d) an interpolated hand image.

POSSIBLE INTERACTION TECHNIQUES

We developed several scenarios to show what kind of new interaction may be enabled by a ThickPad on a laptop computer, and implemented three of them: position-dependent gestures, typing-context gestures, and area gestures.

Position-Dependent Gestures

On a MacBook, a gesture anywhere on the touchpad is sent to a window under the mouse cursor. This means that a gesture in this case is not position-dependent. In order to send a gesture to other window, a user must move the cursor first. With a ThickPad, the system may highlight the window which will get a gesture command based on the hover position of the fingers. A user may now send a gesture to a target window without first moving the cursor to that window. Another example of a position-dependent gesture is a scrolling gesture which may have a different control-display gain depending on the location of the gesture on the touchpad.

Typing Context Gestures

A ThickPad can sense the shadow of hands over it. The system may determine whether a user is in a typing context or not based on the hand image. When both hands dwell on or over the right and the left top parts of the touchpad, the system may declare a typing context. The detection of a typing context will be of practical use for handling the problem of unintended touches by the palm. In addition, the system may interpret the same gestures differently in a typing context. In a typing context, a user may invoke a context menu by a tapping gesture, or move the text cursor around, instead of the mouse cursor, by the finger movement on the touchpad.

Area Gestures

Area gestures by the hand on the laptop touchpad may be easy and intuitive. For instance, a user may cover the left part of the touchpad with the left hand to switch to other application temporarily and use the right part of the touchpad to manipulate the application. A user will return to the main application by removing the left hand from the touchpad. An area gesture like this may be possible with a normal multi-touch touchpad, but will be a difficult gesture as maintaining a large contact area on the touchpad is not a natural operation. With a ThickPad, an area gesture does not require maintaining a large contact area, but require covering an area lightly, which may be as light as a flicking or tapping gesture.

CONCLUSION

In order to explore new possibilities when a hover-tracking touchpad meets a laptop, we implemented a ThickPad and used it to experiment with a few possible scenarios in a laptop environment. While we are yet to carry out a user study, the touchpad prototype turned out to be effective and the application scenarios that we experienced turned out to be feasible. We are currently in the stage of refining the prototype and planning a user study to evaluate the proposed scenarios with users.

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