Enabling tangible interaction on capacitive touch panels

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Enabling Tangible Interaction on Capacitive Touch Panels

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ABSTRACT

We propose two approaches to sense tangible objects on capacitive touch screens, which are used in off-the-shelf multi-touch devices such as Apple iPad, iPhone, and 3M's multi-touch displays . We seek for the approaches that do not require modifications to the panels: *spatial tag* and *frequency tag*. Spatial tag is similar to fiducial tag used by tangible tabletop surface interaction, and uses multi-point, geometric patterns to encode object IDs. Frequency tag simulates high-frequency touches in the time domain to encode object IDs, using modulation circuits embedded inside tangible objects to simulate high-speed touches in varying frequency. We will show several demo applications. The first combines simultaneous tangible + touch input system. This explores how tangible inputs (e.g., pen, easer, etc.) and some simple gestures work together on capacitive touch panels.

ACM Classification: H5.2 [Information interfaces and presentation]: User Interfaces: Input Devices and Strategies, Interaction Styles.

General terms: Design, Human Factors

Keywords: tangible, markers, physical interaction, interactive surface

INTRODUCTION

Tangible User Interface (TUI) enables users to interact with digital information through physical objects [5,1]. For example, tabletop surfaces commonly use the diffuse illumination (DI) optical system, which has cameras below the interaction surface and can "see" the tangible object markers above the surface. The makers encode different patterns in the spatial domain (e.g., fiducial markers) so that system can sense them as different objects [4]. Capacitive touch screens, unlike optical systems, do not have camera under the screen. They sense finger touches by the capacitive coupling effect [1]. Currently, multi-touch devices are generally made by projected capacitive technology (PCT) [3]. Because PCT forms a grid pattern of electrodes to sense the location of finger touch, we can use material or circuits that generate an electric field similar to fingers to simulate finger touches. However, there are two challenges to using spatial tags on capacitive screens. First, devices such as Apple iPad and 3M's multi-touch displays have a limit on simultaneous touches ranging from 5 to 20. Second, current touch-sensing mechanisms would merge close touch points to accommodate fat fingertips. These limitations reduce the number of unique markers that can be represented in spatial domain.

Our second approach, frequency tag, utilizes the faster response time provided by capacitive touch sensing compared to resistive touch sensing and also diffuse illumination. The approach encodes a tag by simulating finger touches at the same position at varying frequency. The simulated touch frequency is much higher than human touch, thus human's finger touch and frequency tags can be differentiated and finger input and tangible objects can be used simultaneously.

Figure 1: Tangible objects, using spatial tags, on a capacitive touch panel

PROPOSED METHODS

Tag design based on spatial domain

Capacitive touch panels can detect certain materials such as conductors. We have created patterns of touch points using these types of material, as shown in Figure 1 and Figure 2. Because PCT panels typically use an X-Y grid to sense the change in capacitance to determine the location of the touch [3], we are currently accessing sensing signals from the low-level controllers to get better signal resolution for each touch point.

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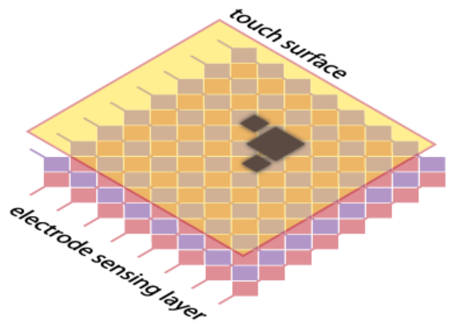

Figure 2: 2D marker design

Tag design based on time domain

The touch-frequency resolution of capacitive touch panels is relatively high, which makes it possible to encode a tag by generating high frequency touches. The number of unique IDs that we can encode is limited by the response rate of PCT screens. For example, if a panel can detect touches at 150Hz, we can have 5-bits tag that allows tangible interaction at a rate of 30fps. The block diagram we have designed is shown in figure 3.

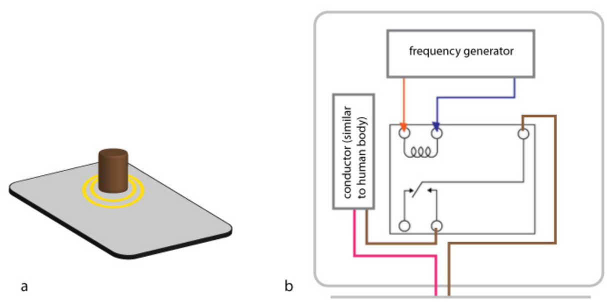

Figure 3: (a) a tangible object on a touch panel (b) a modulation circuit which generate high frequency touches inside the tangible object

Combining spatial and frequency tags

Since there are some limitations in spatial domain and time domain, we will propose a method to expand the usable bits of the tag. At the same time, by combining 2D makers and frequency tag, we can add orientation on frequency tag. This is important for some applications. (e.g., map touring system)

APPLICATIONS

Unlike tabletop systems, current capacitive touch panels are made in smaller sizes ranging from 3.5" to 22". We will propose several applications to explore TUI on these form factors.

Simultaneous TUI + Touch Direct Input

One of the TUI advantages is that it reduces the UI elements on screen. Users no longer have to switch modes by selecting menus or icons on the screen. They can intuitively select and use tangible objects that have the appropriate function. This not only enables more content to be displayed on the smaller screens, but also reduces the learning curve of learning new interfaces. We plan to explore interaction techniques, such as those from "Manual Deskterity" [2], based on using Simultaneous TUI + Touch Direct Input on capacitive touch panel. Figure 4 shows an example that combines a tangible pen input and multi-touch gesture input to draw a straight line.

Figure 4: User can hold different pens (e.g., pencil, charcoal or crayon), and combine 3-finger touch gesture to trigger a virtual ruler to draw a straight line.

VALUE

Capacitive touch panels are compact in size and lightweight, and have grown extremely rapidly. However, little prior work has studied how TUI can be achieved on capacitive touch panels. Our contribution includes the two tag sensing technology that enables tangible interaction on capacitive touch panels, and we are in the process of designing a tangible toolkit for developers.

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