PUCs Demo: Detecting Transparent, Passive Untouched Capacitive Widgets on Unmodified Multi-touch Displays

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ABSTRACT

Capacitive multi-touch displays are not typically designed to detect passive objects placed on them. In fact, these systems usually contain filters to actively reject such input data. We present a technical analysis of this problem and introduce Passive Untouched Capacitive Widgets (PUCs). Unlike previous approaches, PUCs do not require power, they can be made entirely transparent, and they do not require internal electrical or software modifications. Most importantly they are detected reliably even when no user is touching them.

Author Keywords

Tangible user interfaces; transparent widgets; passive widgets; tabletop interaction; capacitive multi-touch

ACM Classification Keywords

H.5.2 Information Interfaces and Presentation: User Interfaces Input Devices and Strategies

INTRODUCTION

Most modern multi-touch devices use capacitive technology to detect users touch input. Tangible widgets for such systems where introduced by Rekimoto in 2002 [4]. Other systems such as the CapWidgets [3] and Capstones [2] extend this first approach. However, all these widgets have one common drawback: the rely on the human body capacitance to be detect by the touch screen. This means they can only be detected if a user touches them. This leads to several problems: it is not possible for the system to distinguish whether the object has been lifted form the screen, or the user is no longer touching the widget. Furthermore, if a widget is moved without being touched, for example, by flicking the widget, this movement cannot be detected by the touch screen as well.

In this demonstration we present *Passive Untouched Capacitive Widgets (PUCs)*—simple physical widgets the can be detected by an unmodified capacitive touch screen without being touched by a user. We will explain how these PUC widgets are detected by the screen. Furthermore, we show how the can be made totally transparent.

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Figure 1. PUC widgets on an iPad: a transparent Bridge PUC (left) and a Ring PUC (center). The clip to permanently ground a touch point and override the iPad's adaptive filter can be seen on the right.

CAPACITIVE TOUCH DISPLAYS

Capacitive touch displays are able to sense a grounded electrical conductor, a human finger, which is close to the display [1]. A typical capacitive display consists of a set of row electrodes and a set of column electrodes. Electrodes in one of these sets act as transmitters (Tx) while the electrodes in the other set act as receivers (Rx). If a signal is applied to one Tx electrode, at each intersection between this Tx electrode and each Rx electrodes, a capacitive coupling is established. We refer to these intersections as active. The coupling is measured by each Rx electrode. By activating only one Tx electrode at any time the system is able to measure the capacitance of each intersection individually.

If a grounded conductor such as a finger comes close to one of the intersections, the coupling between both electrodes at this intersection is disturbed such that the measured capacitance for this intersection is reduced. With this method the display controller is able to determine the shape and center of the contact point, by using interpolation between multiple intersection.

However, this signal is noisy and commercially available capacitive displays are optimized to detect only human fingers as touch points. To accomplish this, the display controllers apply a set of filters to identify these human fingers by searching for elliptical shapes and signals that influence the capacitance of an intersection in the same way a human finger that is touching the display surface does.

HOW PUCS WORK

We found out that a widget has to fulfill basically two requirements to be detected as a touch point by a capacitive touch display: (1) It has to reduce the capacitance of the intersection in the same way as a human finger would. (2) The shape of the contact point has to be elliptical with a size similar to a fingertip.

The current method to accomplish this is to place a conductive widget on the display and let the user touch it [4]. While the user is touching the widgets, the widget is electrically grounded.

Alternatively, PUCs do not need to be electrically grounded by a user or by a external grounded object to be detected by a capacitive touch display (Fig. 1). Instead they ground themselves by electrically connecting multiple active and inactive intersections. While the active intersection is scanned, the inactive intersection serves as ground. This grounding is strong enough to disturb the capacitive coupling at the active intersection enough such that the system detects the contact point of a widget as a touch.

The simplest PUC widget is shown in Figure 2. It consists of two round *pads*, that fulfill the second requirement, and a conductive "Bridge" that connect both *pads*. As shown in Figure 1 a "Bridge" widget can be made totally transparent by using an *indium tin oxide* (ITO) foil for the pads and the connection between them. When a Tx electrode under one pad is currently active and the Tx electrodes under the other pad is inactive (at ground level), this second pad has a capacitive coupling to ground. This ground coupling is sufficient to reduce the $Tx - Rx$ intersection capacitance under the first pad to below the threshold for touch detection. Similarly, when the Tx electrodes are active under the second pad (when the touch screen scanning algorithm reaches that area), the Tx electrodes under the first pad will no longer be active, and thus coupled to ground. This lets the Bridge PUC generate one touch event for each of the two pads, without the aid of external grounding.

However, if both pads are aligned with one Tx or Rx electrode both pads will not be coupled to electrical ground. In fact instead of decreasing the capacitance of the active intersection, the capacitance is increased by creating a strong coupling between Tx and Rx. Conceptually, this leads to the problem that non of the pads is detected as touch point.

To address this alignment problem we created a "Ring" widget (shown in Figure 1). This widgets consists of a set of pads that are connected with a ring-shaped conductive material that hovers above the surface. Since the capacitive field reaches out of the display the hovering conductive material also creates a capacitive coupling to the inactive intersection under it. This setup ensures that parts of the widget are not aligned to a single Tx or Rx electrode, independent of the widget orientation.

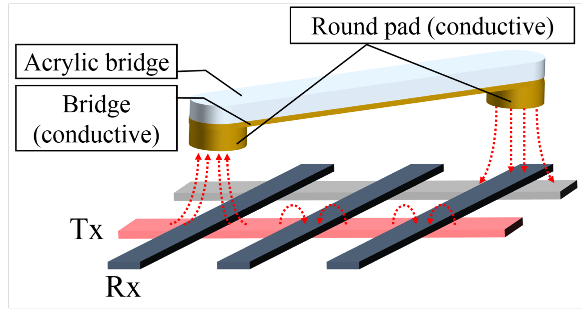

Figure 2. Basic concept of a Bridge marker. Red connections indicate capacitive coupling between marker and electrodes.

LONG-TERM DETECTION

We found out that most capacitive touch screens adapt their filtering algorithms to changes in electrical background noise. Since a PUC widget only reduces the capacitance of the intersection barely below the threshold to be detected as a touch point, this adaption tends to remove the detected touch points after 20 seconds.

However, for several devices, such as the iPads, this adaption algorithm can be disabled by placing a touch point somewhere on the screen that has a connection to a large ground potential, for example the battery of the iPad. This can be accomplished by a conductive clip that is connected to the aluminum back of the iPad, as shown in Figure 1.

CONCLUSION

In this demonstration proposed *PUCs,* tangible widgets for capacitive multi-touch screens that (a) are *passive* and require no batteries; (b) can be detected even when *untouched*; (c) can be completely *transparent*; and (d) work with *unmodified* off-the-shelf multi-touch screens. Our contributions also include (e) the new approach of grounding a widget via a second pad or hovering conductive material plane.

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