SLAPbook: tangible widgets on multi-touch tables in groupware environments

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ABSTRACT

We present SLAPbook, an application using SLAP, translucent and tangible widgets for use on vision-based multi-touch tabletops in Single Display Groupware (SDG) environments. SLAP stands for **S**ilicone **IL**luminated **A**ctive **P**eripherals and includes widgets such as sliders, knobs, keyboards, and buttons. The widgets add tactile feedback to multi-touch tables while simultaneously providing dynamic relabeling to tangible objects using the table's rear projection. SLAPbook provides multiple users the ability to add and edit content to a guestbook, browse other peoples' entries, and access personal data using a token-based personalization system. Interaction with the table takes place in the personal and public space so that users can make use of personal and shared controls to perform separate and coordinative actions.

Author Keywords

multi-touch, tangibles, groupware, tabletop, transparent controls, widgets

INTRODUCTION

Multi-touch displays provide versatile and natural surface interactions for Single Display Groupware (SDG) applications. In contrast to most Computer Supported Cooperative Work (CSCW) and multi-user software applications, Single Display Groupware have users in the same place at the same time rather than dispersed across space or time. Users may also share input devices (such as a mouse and a keyboard), have their own, and/or engage in activities not requiring them. Common themes include awareness, separate and coordinative actions, shared and personal controls.

Using multi-touch, people can work together. They can directly and simultaneously interact with graphical content using bare fingers, styli, and tangible objects, both individually and in coordinated groups. Graphical objects may be modified and shared by multiple people, passed to a specific person or location, claimed, or otherwise modified through aspects of group dynamics. However, while graphical objects are capable of dynamics not possible with physical objects, they also lack the tangible benefits of physical interaction.

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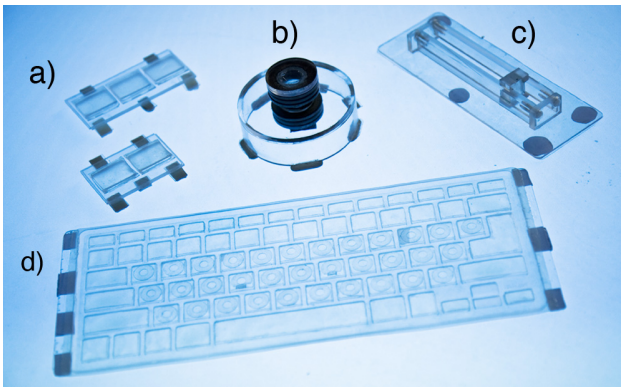

Figure 1. SLAP Widgets. a) Keypads with two and three buttons. b) Knob. c) Slider. d) Keyboard.

SLAP Widgets extend multi-touch displays with a variety of physical controls and blend the tangible qualities of physical objects with the dynamic qualities of virtual graphics. Their optical transparency supports "viewing through" and their physical flexibility permits "pressing through". They are low-cost, contain no electrical parts, and require no tethering to power supplies. Only tactile materials are necessary. Furthermore, SLAP Widgets (see Fig. 1) support and enhance group and individual activities, such as "blind" use, enabling interaction without interruption of visual attention.

To demonstrate some of these advantages, a guestbook application, SLAPbook, was developed. Although guestbooks are not traditionally considered groupware applications, we hope our re-interpretation will provide a memorable experience as well as a demonstration of groupware widgets.

RELATED WORK

Tangible Tiles of Waldner et al. [7] uses optically tracked transparent plexiglass tiles to provide a tangible container representing virtual objects and controls. These tiles can be freely moved and orientated on the table, but their shape is not indicative of their intended purpose.

Handoff is frequent in face-to-face interaction on tabletops. Subramanian et. al [5] presented an experimental study of different interaction techniques, finger gestures or physcial controls, for supporting handoff within groups. As a result,

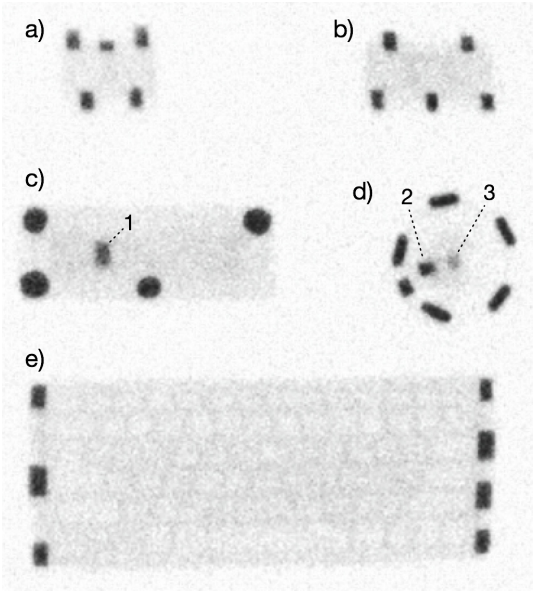

Figure 2. Footprints of SLAP Widgets (image has been inverted for better perception). a-b) Keypad with two and three buttons. c) Slider with sliding knob (1). d) Knob with angle indicator (2) and push indicator underneath the rotation axis (3). e) Keyboard.

they suggest that using physical controls improves the performance of handoffs.

Morris et al. [4] evaluated how different placements of widgets affects usability for co-located tabletop groupware applications and revealed users' preferences for replicated controls over shared controls.

Browsing photographs on tabletops was explored by Hinrichs et al. [1] in a fluid interface which automatically reorientates pictures as they move circularly around the table. When users sit on different sides of the table, such an interface more readily facilitates data access and sharing.

Kaltenbrunner et al. [3] evaluated group collaboration with reactable, a multi-user musical interface for changing parameters of a sound synthesizer. They reveal two collaboration styles; spatial separation where each user plays in his personal space and shared space where players make music in a real collaborative process.

We aim to demonstrate the benefits of transparency, tangible sharing, replicated controls, and the use of personal and shared spaces with a guestbook application using a multi-user, multi-touch SLAP framework.

SLAP SYSTEM DESIGN

SLAP Widgets are made of transparent acrylic or silicone and include keyboards, knobs, sliders, buttons (see Fig. 1), and tokens. Our multi-touch table uses a combination of frustrated total internal reflection (FTIR) to detect touches and Diffuse Illumination (DI) to sense reflective patterns and uniquely identify "footprints" (see Fig. 2) under each SLAP widget. Positions of knobs and sliders also use reflectors to convey their positions. The table's rear projection displays graphics under the widgets, enriching the physical interface with dynamic labels (cf. Fig. 3). Portraits of users are captured using a *wireless camera* placed on the table surface. Its position and orientation are identified with fiducial markers underneath it. To uniquely identify individual users, fiducial markers are also placed beneath *souvenir tokens*.

Figure 3. Dynamic relabeling of SLAP Keyboard.

SLAP Widget Set

Although endless possibilities exist for potential widgets, we choose to focus our attention on a small subset consisting of buttons, knobs, sliders, and keyboards because they are ubiquitous controls in physical interfaces. The **SLAP Keyboard** is a flexible tactile membrane supporting pressing through to the table and adds tactile feedback to tabletop interactions. The **SLAP Keypads** work in a similar way, are fabricated as two and three button variations, and may aggregate to form larger keypads as needed. The acrylic **SLAP Knob** can be rotated and pushed to display a circular menu under the base of the knob (see Fig. 5a). By turning the knob the user can step through menu items or change parameter values (see Fig. 5b) and confirm a selection by pushing the button again. The **SLAP Slider** (cf. Fig. 2c) is a conventional slider control with its current value and range projected underneath.

Pairing

SLAP Widgets are general-purpose controls that adopt functionality when mapped to virtual objects on the table. Mappings may be either system defined or created/removed using a bimanual symmetric synchronous double-tapping gesture on both the widget and the object. The table projects colored halos around the widgets, indicating connection states. The halo flashes either red to indicate a failed connection, green to indicate a successful connection, or blue to indicate default state. Upon connecting, the control graphics are displayed under the widget which is then ready for use. Pairings remain persistent within a session, permitting users to remove and replace widgets from the table as desired. This enables easy handover between multiple people and the ability to move them onto the rim to reduce clutter. A pairing is disconnected by repeating the double tapping gesture.

INTRODUCING SLAPBOOK

Guestbooks are fairly common in public and personal environments where people can enter quick thoughts, greetings, and criticisms. In contrast to physical guestbooks, multiple

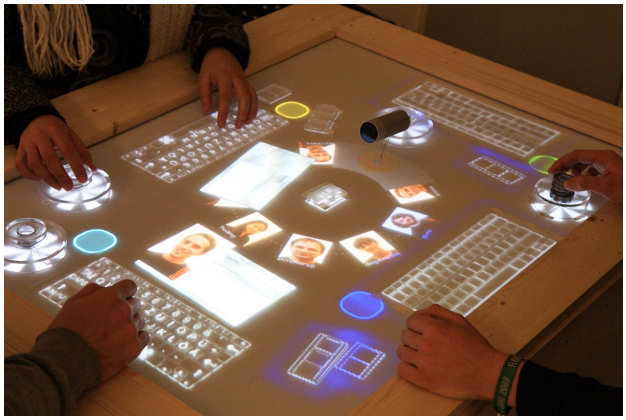

Figure 4. SLAPbook concept.

people can simultaneously look at different entries and create new ones within SLAPbook. We give a general overview of the SLAPbook interface followed by a more detailed description in the usage scenario section. In the center of the table sits a wireless camera surrounded by a circular, public browser of SLAPbook entries (see Fig. 4). The periphery can be used as a personal space to have a closer look at a single entry or edit personal information. Every person receives a souvenir token that is uniquely identified when placed in any of the four personal spaces of the table. These tokens secure access to personal information, identify a users location at the table, and create default widget pairings for their set of personal controls (consisting of a keyboard, keypad, knob, and slider). These pairings are dynamic, easily modified, and thus may become personally unique controls rather than replicated controls. Users without a token on the table may interact with the shared space only. Within this shared space is a public SLAP Knob for navigating the public browser. Unlike the personal widgets, this SLAP Knob is shared and passed around within the shared space of the table (cf. [4]). Personal SLAP Knobs may also be dynamically paired to the public browser replicating the public knob. Furthermore, there resides a SLAP Keypad in the shared space which has a static pairing to the camera controls. Unlike shared navigation, the pairing for camera control is exclusive and may not be replicated by personal widgets.

When a user engages in individual activities, SLAPbook temporarily extends their personal area over the portion of the public browser closest to them [6]. For example, entities such as text editors overlap portions of the shared area and obstruct only the content a user is no longer attending to. Other users can still clearly see shared images oriented towards them and lose view only of images not oriented towards them. In some cases, such as displaying profile details associated to a portrait, overlap between shared and personal spaces is a meaningful gradient between shared and personal activities. Additionally, awareness of when others are engaged in individual activities is increased.

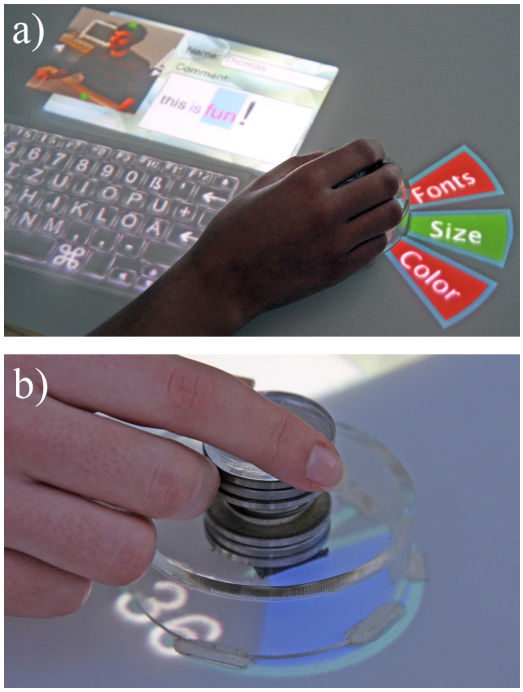

Figure 5. Interaction with SLAP Knob when paired with a SLAPbook entry. a) After pairing the user may choose between different parameters in a pie menu by rotating the knob. b) When pushing down the plate the selected parameter can be set by rotation. Another push returns to the menu.

Usage Scenario

John and Julie are conference attendees. Julie approaches the table first. She receives one of the souvenir tokens from the demonstrator. John already has a token from his last visit. Julie puts down her token onto the table at one of the free workplaces and a new entry to the SLAPbook appears in front of her. She notices the SLAP Widgets in her personal space: a SLAP Keyboard which is paired to her SLAPbook entry and a knob which is paired to the browser. While Julie is entering her name using the keyboard, John rotates the public knob in the middle of the table, curious who already has visited the table. Meanwhile, Julie writes a note to greet other conference attendees. In order to improve the visual appearance of her entry, she pairs the SLAP Knob with her SLAPbook entry and formats the text (see Fig. 5). Afterwards, she again pairs her knob with the browser and notices while scrolling that John is simultaneously browsing through the book. Since Julie turned her knob to the right and John to the left, their scrolling intentions nullified each other. In a short verbal agreement between each other, they agree to the “ladies first” principle. While Julie is scrolling, John spots an entry of his collegue. He stops the scrolling by holding down his hand to the entry overwriting all other actions. Then he drags out a copy of the entry to his personal space to have a look at it. Feeling cluttered, John moves several widgets to the rim of the table.

John decides that he wants to add a picture to his SLAPbook entry. John puts down his token and his previous entry ap-

pears. He turns the wireless camera in the center of the table into his direction, pushes the trigger on the keypad next to it, and a 3-second count-down gives him time to adjust his position for the picture. After John and Julie are done, they take their tokens from the table. Every entry in their personal space slides back to the SLAPbook and disconnects all existing widget pairings, leaving the table free for future visitors.

DISCUSSION

There are several concerns expected when using multiple tangible objects with multiple people at a table such as claim of ownership, real estate, handoff, and awareness. We discuss each of these problems and show how this could be solved by SLAP.

Claim of Ownership. Sometimes people lose track of their objects when multiple tangible objects are scattered over the tables. Especially on smaller tables the user rearranges the controls depending on where the current task takes place. This interferes with the space of other users and leads to confusion about the ownership. One of the benefits of the tangible and dynamic modifiable SLAP Widgets is making hidden aspects visible. Using visual clues such as colors the ownership could be indicated.

Real Estate. Tangibles on multi-touch tables can become cluttered, especially in SDG environments. Conventional tangibles only provide the possibility of putting them away from the table to make room. However, the transparency of SLAP widgets affords the visibility of virtual objects through them when needed. For example, a user drags over a virtual object to her personal space. A SLAP Keyboard positioned in front of her takes the space she would need for inspecting the object, but due to the transparency of the keyboard she can simply drag the object over the table's rear projection and see through the transparent physical SLAP Keyboard.

Handoff. Digital handoffs initiated by a sender or receiver can be improved [2], but they are not likely to match the convenience of passing actual tangible objects. SLAP Widgets, however, enable the handoff of the actual controls rather than a physical or virtual representation of them. They provide the best of both worlds. Hand-overs may be accomplished with logical relocation of function as well as physical relocation of control. Therefore, a functional pairing may be replicated or transferred from one widget to another.

Awareness. Tangible SLAP Widgets may be operated blindly. The visual attention of a user is free to observe gaze and activities of others as well as the effects of their actions on others; users are able to attend to the activities of the table rather than their manipulation of a control. Additionally, tangible hand-over of SLAP Widgets between users provide awareness opportunities for all.

FUTURE WORK

We seek to extend the SLAPbook project to explore issues of multiple people using tangible workgroup widgets on multi-touch tables, specifically conflicts arising from shared control, limited table space, transparencies and object/widget overlap, dynamic arrangements of controls, and awareness of actions and capabilities.

Mapping multiple controls to a common object parameter engages many of these issues and areas of future development. Widgets may have exclusive mappings to parameters complimented by mutual awareness of others also wanting to modify a parameter and dynamically negotiate transfer or share control. Widgets may also be designated as primary influence controls, in effect over-riding all other widgets as default, egalitarian controls.

Controls may also be mapped to multiple object parameters, either changing parameter values in parallel or dynamically switching between different parameters. Widgets may themselves become modifiable mapping targets of other widgets, such as a keypad selecting a parameter for a knob. Thus, passing a keypad around becomes a means of passing mappings between individuals.

The interconnectivity of actions and artifacts is rarely simple, nor is their arrangement or use of space, particularly in collaborative environments. We look forward to exploring these issues and the future contributions of SLAP Widgets.

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