Cell Selection for Spreadsheets on Tablets: Stacking-Based Interaction

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This work has been carried by a Berger-Levrault/IRIT collaboration.

Abstract

Spreadsheets on tablet, based on multitouch interaction is tedious and raises multiple interaction issues such as screen size or limited tactile interaction. To answer this limitations, we propose the use of the stacking paradigm, which consists in laying one edge of a smartphone on a tablet screen. It offers the double benefit of augmenting the input vocabulary and extending the display surface. We built a prototype based on a 3D printed shell augmented with copper to detect the smartphone on the tablet screen. We also developed a simplified spreadsheet app on the tablet in which users can select cells using three stacking-based interaction techniques.

Author Keywords

Mobile interaction; Spreadsheet; Stacking.

ACM Classification Keywords

H.5.2. Information interfaces and presentation: Interaction.

Introduction

Spreadsheets are highly popular as reflected by their 55 million users in the United States in 2012 [6]. These applications are also widely used in mobile devices, with over 100 million downloads for Excel on Android. However, the limited display size (inducing multiple pans and views switching) and, most of all, the limitations of touch interaction (i.e. few gestures which
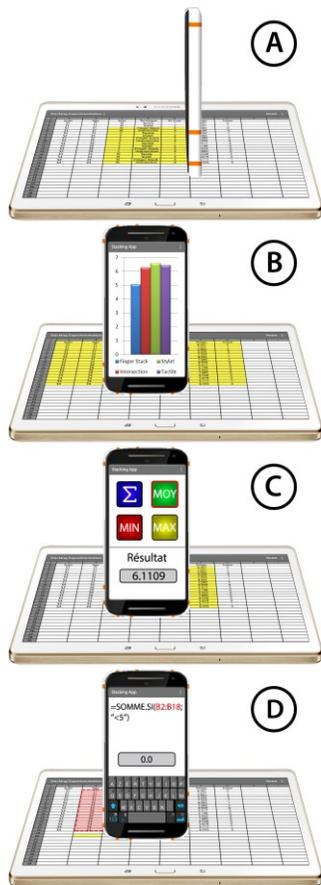
Figure 1: Illustration of the stacking of a smartphone on a tablet screen for spreadsheet tasks: cell range selection (A), chart visualization (B), mean calculation (C) and cell edition (D).

are mostly bound to spreadsheet navigation) fail at providing a convenient solution to interact with spreadsheet on tablets.

Previous work proposed multi-touch gestures [1,8] to extend the touch vocabulary on tablets. However their memorization can be difficult and the menus and sub-menus openings may occult data. Another way of extending input DoFs is to combine touch with pen input [2,5]. Nonetheless, parallel viewing of raw data and charts remains limited. The combination of a smartphone and a tablet or a large screen has also been considered [3,9]. Based on the smartphone position detection or tag recognition, these approaches rely on external systems, which restrain their adoption outside research environments.

As an alternative, other works [4,7] propose the use of a smartphone as a tangible interactor by relying on a smartphone copper shell or a sensor fusion algorithm. These ad-hoc stacking-based interaction techniques appear very promising to facilitate the access to commands and allow a parallel viewing of multiple data.

We thus propose to use the smartphone with the stacking paradigm. It consists in bringing in contact one edge of the smartphone with the screen of the tablet running the spreadsheet app (Figure 1). The potential is threefold: 1) the initial display area is extended with a second screen; 2) touch vocabulary is extended through smartphone manipulations; and 3) stacking techniques preserve all the original touch interaction. Based on the stacking paradigm, we propose three interaction techniques for a central task in spreadsheet usage: cell selection.

Stacking: Design Dimensions

Through participatory design sessions with four users, we first seek to identify ways for taking advantage of the stacking paradigm using a smartphone and a tablet. We extracted three main dimensions for designing stacking based techniques when combining a smartphone and a tablet:

Contact area: The four edges and corners of the smartphone can be stacked on the tablet screen. The front and rear faces of the smartphone could also be stacked, but the smartphone would then occlude an important part of the tablet screen, we thus voluntary discarded these types of contact.

Smartphone manipulation: The two delimiting manipulations of stacking are stack (i.e., lay a smartphone edge/corner on the tablet screen) and unstack (i.e., lift up the smartphone). With a stacked smartphone, the user can 1) perform a set of finger touch on it (tap, drag or pinch/spread), 2) apply physical motions to it (translation, flat rotation, tilt and corner rotation, Figure 2) or 3) produce compound (physical then touch) manipulations.

Interaction technique: Input interaction can be performed on the spreadsheet through finger touch, smartphone stacking contact or a combination of both.

Interaction techniques for Cell Selection

Cell selection is a central task in spreadsheets, required for most of commands. We designed three stacking-based techniques for cell selection based on three different values of the *Interaction technique* axis.
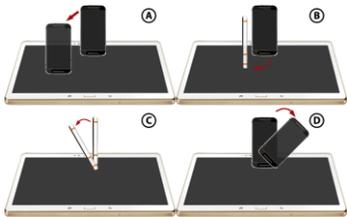
Figure 2: Smartphone manipulations: Translation (A), flat rotation (B), tilt (C) and corner rotation (D).

Figure 3: Copper-based case (top). Stacking of our prototype on the tablet screen (bottom).

Intersection

This technique consists in intersecting rows and columns using solely stacking actions. To select a range of cells, the user stacks the smartphone over the start column (respectively row) to be selected, with a vertical orientation for columns (respectively horizontal orientation for rows) (Figure 4). These two steps are independent and can be performed in any order. The intersection between the set of selected rows and columns defines the range of selected cells. In both cases, translating the smartphone extends the selected range of rows/columns.

Stack-and-Drag

The *Stack-and-Drag* technique is based on a stylus metaphor: the center of the smartphone stacked edge acts as a pointer on the tablet. To prevent occlusion issues, this pointer is represented by a red dot displayed on the tablet screen shifted 1cm in front of the contact edge of the smartphone (Figure 5 – Left). To select the top-left corner of the cell range, the user stacks the smartphone on the tablet screen. Translating the smartphone extends the current cell selection (Figure 5 – Right). Re-stacking on one corner of the selection can be used to adjust the selection.

Finger Stack

The *Finger Stack* is a bimanual technique that consists in defining the top-left corner of the cell range with a finger touch (Figure 6 – Left) and the bottom-right corner with the smartphone stack (Figure 6 – Right). The bottom-right corner is selected using the red dot feedback as in the *Stack-and-Drag* technique. The two corner cells positions can be adjusted with a finger drag and/or a translation of the smartphone.

For all techniques, when the range to select exceeds the screen limits, dragging the smartphone close to the tablet screen limits activates auto-scrolling (Figure 7).

Stacking: Prototype Implementation

We 3D-printed a smartphone case and augmented it with copper strips (5-6mm width) on every edge (Figure 3). The tablet detects these strips as three simultaneous touch events and identifies them as a stack event. As there is no common touch gesture requiring three touch inputs at the same time, the stacking does not interfere with touch interaction. By controlling the relative distance between these strips, we can create a unique pattern for each edge, thus allowing the tablet to identify which edge of the smartphone has been stacked.

Demonstration App

To assess the performance of our stacking-based techniques, and as the existing excel app is not an open software we developed an app that reproduced exactly the same behavior than the original one for the main features: rendering, cell selection, scroll, pan and zoom. In our app, users have to select a range of cells using our interaction techniques or the regular touch interaction. To represent the diversity of cell ranges, we considered seven categories: complete rows, complete columns, 1xM (one column only), Nx1 (one row only), NxM (square, horizontal and vertical rectangles. After a first pop-up, showing the information relative to the required selection range, users can start the trial, which displays a spreadsheet. The headers associated with the targeted cell range were displayed in red. Once cells are selected, if they are included in the targeted range, the corresponding headers are displayed in green. Otherwise, they are displayed in yellow, thus

Figure 4: Intersection technique: stack (1) and translation (2) to select columns and stack (3) and translation (4) to select rows.
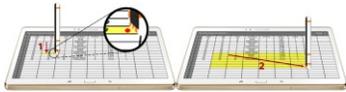
Figure 5: Stack and Drag technique: stack of the smartphone (1) and translation (2) to extend the selection.

Figure 6: Finger Stack technique: touch to select the top-left corner (1) and stack to select the bottom-right corner (2).

Figure 7: Vertical (left) and horizontal (right) scroll. The green area represents the scroll-trigger area.

highlighting a mistake. Once the target range is correctly selected, an automatic validation of the trial is triggered after 500ms to prevent false positive.

To assess the performance of our techniques (selection time and usability), we conveyed a user study with 12 participants. Our results tend to show that *Intersection* and *Finger Stack* allows range selection 15% (resp. 20%) faster than traditional touch interaction. Furthermore, the *Intersection* technique had a SUS score similar to touch interaction. These results appear promising for future exploration of stacking-based interaction for spreadsheets on tablets.

Conclusion and Future Work

We presented different multi-device techniques to facilitate interaction with spreadsheets on tablets. Our techniques are based on stacking a smartphone on a tablet screen. Our contribution unveiled major design considerations for such techniques and we designed a copper-based case that allows the detection of the smartphone on the tablet screen. We designed stacking-based techniques for cell selection and a spreadsheet app on the tablet to assess the performance of these techniques.

Acknowledgements

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