Social and Spatial Interactions: Shared Co-Located Mobile Phone Use

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Abstract
This paper outlines the design of the *Social and Spatial Interactions* platform. The design of the platform was inspired by observing people's pervasive use of mobile technologies. The platform extends the current individual use of these devices to support shared co-located interactions with mobile phones. People are able to engage in playful social interactions on any flat surface by using devices fitted with wireless sensors that detect their current location with respect to each other.

Keywords
Co-Located Interaction, Sensor Network, Mobile Phone

ACM Classification Keywords
H.5.m Information Interfaces and Presentation (e.g., HCI): Miscellaneous.

General Terms
Design, Experimentation, Human Factors.

Introduction
Mobile phones were originally conceived and have traditionally been utilized for personal use. The improvement in wireless networks and handheld computing platforms offers possibilities to explore

Figure 1. A probe participant checking his email while in bed.

Figure 2. Two participants sharing the same table using their laptops.

Figure 3. Kapteeni, a distributed memory game that was demoed during the co-design sessions.

shared use of mobile phones. In this paradigm shift, co-located users engage in collaborative activities using their devices, thus going from *personal-individual* towards *shared-multiuser* experiences and interactions.

In this paper we present the *Social and Spatial Interactions (SSI)* platform that was inspired by observing people's daily interactions with current mobile technologies (i.e. laptops, mobile phones, MP3 players). The platform supports shared co-located interactions, using the mobile phone as a physical interface and a sensor network built in the phone to track the position of the phones on a flat surface.

The paper is structured as follows. First, we provide background information and discuss related work. We then introduce the principles behind *SSI,* followed by a description and evaluation of the *MindMap* prototype. Finally, we present conclusions and future directions.

Background

The *'Playful Interactions'* project tries to build an understanding of the role of playfulness in the overall user experience of a product or service. We are following a user-centered design (UCD) approach by involving end-users in the process of coming up with new playful artifacts and interactions. We have conducted a probes study, co-design sessions, and evaluations of prototypes.

Probes Study

For our probes study [3] we invited 14 international students (mix of native Finnish speakers and others) who had different needs in terms of socializing and communication (i.e. friends and families living abroad). The purpose was to find new opportunities for playful interactions inspired by the needs, dreams and aspirations of our user group. In this study, we witnessed people's pervasive use of (mobile) technologies. Participants reported things like checking Facebook or their email (Figure 1) as the first thing they do in the morning (before brushing their teeth or taking a shower), or people using their laptop sharing the same table, constantly switching and transitioning between an individual and a social situation (Figure 2).

Related Work

Tangible user interfaces (TUIs) allow people to interact with digital information by manipulating physical objects where the data is coupled with the object [7]. Bricks [2] introduce the notion of 'physical handles' to manipulate virtual objects. DataTiles [10] build on that notion by projecting data on a transparent modular tile. Others like the I/O Brush [11] take on a different approach by using everyday physical artifacts to suggest interaction semantics. Most of these systems require complex projection displays to couple the information onto the object. In this work we explore the use of a mobile phone as a physical interface to manipulate data.

Luyten et al. [8] have studied ad-hoc co-located collaborative work using mobile devices. Personal displays are tracked and used to share a common information space, providing 'peepholes' to the data set. Their setup requires external equipment in the form of 3 infrared towers for 3D tracking of the devices. Siftables [9] are perhaps the closest to our work. This TUI consists of a group of compact display devices that communicate wirelessly and form a sensor network. The main differences are that Siftables were developed with a single user in mind and they are able to detect

Figure 4. Exploring a list of songs by moving the phone on a table.

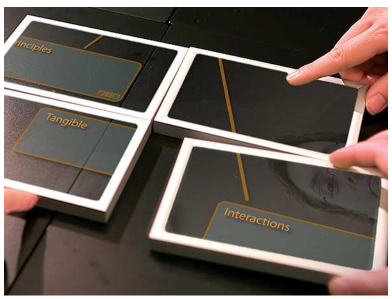

Figure 5. Expanding the viewing area by juxtaposing the devices.

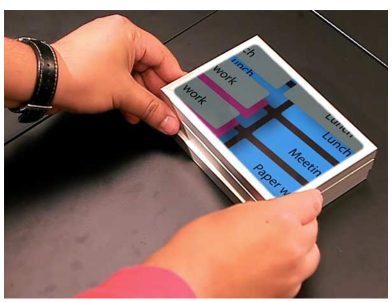

Figure 6. Stacking phones to perform a combined calendar search for a free slot.

where other Siftables are only when placed adjacently one next to the other. We provide a 3D tracking solution that is built in the phone and that allows us to detect where phones are with respect to each other.

Social and Spatial Interactions (SSI)

Based on our previous findings from the probes study, we explored new ways of using mobile phones, from a *personal-individual* to a *shared-multiuser* use. The main principles of *Social and Spatial Interactions* (SSI) are:

- **Social:** We support joint multiuser interactions by encouraging people to share their devices to create an experience or reach a goal.
- **Spatial:** We support interactions that depend on knowing the relative position between phones on a flat surface. Sensors built in the phone provide the necessary tracking.
- **Tangible:** The platform relies on people's ability to handle physical objects. The phones are used like Lego blocks to interact with digital information by performing simple actions (e.g. move, sort, group, join, spin, stack, etc.).
- **Multimodal:** We use touch (i.e. touchscreen) and manual gestures as the two main user input modes. We provide multimodal feedback during the interaction, not only through visuals, but also haptics and sound.

Co-Design Sessions

We implemented a simple demonstrator showing the possibilities for *SSI.* Following our UCD approach, we invited 5 participants from the probes study to: 1) share and validate our probes' findings, and 2) witness the *Kapteeni* demo. *Kapteeni* (Figure 3) is a distributed memory game in which the objective is to repeat a random sequence of button presses that keeps increasing in length. After the demo, participants and 3 researchers engaged in brainstorming sessions. This work resulted in 20 possible application areas for *SSI*.

Interaction Techniques

We identified an initial set of interaction techniques for the *SSI* platform.

- **Exploring:** Using a peephole interface where the phone is used as a window into a virtual space [1,12], users could simultaneously browse a common information layer by moving the phones on a flat surface (e.g. a list of songs) (Figure 4), or browse a different layer each (e.g. a map, Excel sheet, calendar).
- **Expanding Viewing Area:** Users could collaboratively expand the viewing area by placing their phones next to each other (Figure 5). As a result, the displays would be dynamically tiled together [5].
- **Multiple Annotations:** Users could share their actions (e.g. typing or drawing with the finger on the touch display), which would then be pushed and displayed onto the other devices.
- **Spinning:** Using the horizontal surface as support, users could quickly spin the mobile phone while lying flat on its back. This action could be used to delete something, perform a random search, or throw the dice in a game application.
- **Stacking:** Placing two or more devices on top of each other could be used to create something new by combining what is in each device individually (e.g. mixing two pictures). Stacked devices could also be used for combined searches (e.g. simultaneously displaying the calendar entries of different people to find an available time slot) (Figure 6).

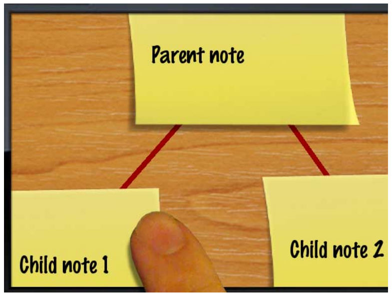

Figure 7. Three notes of the MindMap and its connections in red.

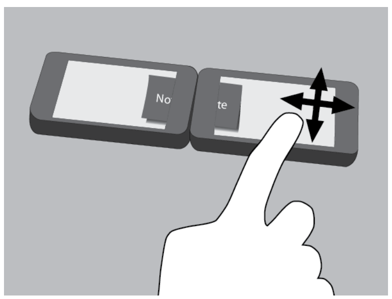

Figure 8. Panning the view on two devices that are joined together.

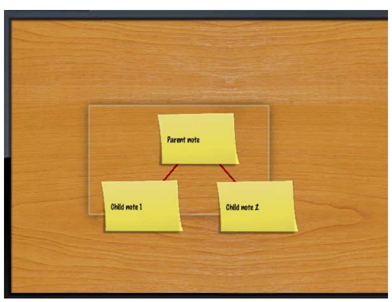

Figure 9. A table overview is shown when the phone is picked up. Other devices on the table are shown as a white rectangle.

Prototype: MindMap

We decided to implement an application that would allow us to demonstrate the potential of the *SSI* platform and some of its principles. We took one of the 20 applications that were identified in the co-design sessions and implemented it. The *MindMap* prototype is a brainstorming tool that allows a workgroup to create, edit, and view virtual notes on any table, not requiring hanging Post-it notes to a board or wall. We use an office metaphor to suggest interactions semantics.

Design Principles

At this point, we were unable to track the relative position of the phones. Therefore, we designed interaction techniques that encourage users to share their devices and use them in collaboration, to compensate for the lack of tracking the physical position of the devices. The phones are used as tangible objects by moving them on the table, grouping them together, and picking them up in your hand to perform gestures. We use two input modes: finger gestures on the touchscreen and manual gestures holding the phone. Feedback is provided in the form of on-screen visuals and sound.

Interaction Techniques

- **Create Note:** To make a new note, users must do a long press on the touchscreen on an empty part of the office-table representation. Text can then be added to the note with the physical flip keyboard. Tapping the display results in placing the note on the table.
- **Edit Note:** A long press on an existing note sets the note in *edit mode.* Visually, the note is displayed suspended in the air and enlarged to optimize text input. Users can again edit the text with the flip keyboard. To change the position of the note, users must drag their finger on the touchscreen, which results in panning the view while the note remains stationary. While one user is editing the text, another can move the note on another device. The note is placed back down on the table and *edit mode* is ended by tapping the display. While editing a note, users can also pick up the device from the table. A scaled-down version of the note is displayed with a partial view of the mind map behind it. Putting the phone back on the table ends the *edit mode.*
- **Connect Note:** Connections between notes can be created and edited by entering the *edit mode* and moving the note using the finger on the touchscreen so that it touches an existing note. This results in establishing a connection with that note. The connection is displayed as a red line (Figure 7).
- **Expand View Area:** Two or more devices can be joined together to create a larger view area (Figure 8) by performing a simultaneous touch gesture on both devices.
- **See Overview**. Picking up the device from the table results in displaying a scaled-down overview of the table (Figure 9). Other devices on the table that are showing the full-size view of the mind map, are displayed on the overview as a white rectangle.
- **Panning the View:** Panning is achieved by dragging a finger on the touchscreen. All users are allowed to pan the view on any of the devices. However, as the view is shared between all the devices, only one user can pan the view at a time.
- **Delete Note:** In *edit mode*, flipping the phone upside down results in deleting the note. As the screen is then no longer visible, a trashcan sound is played.

Figure 10. Evaluation setup with three participants interacting with the devices on the table.

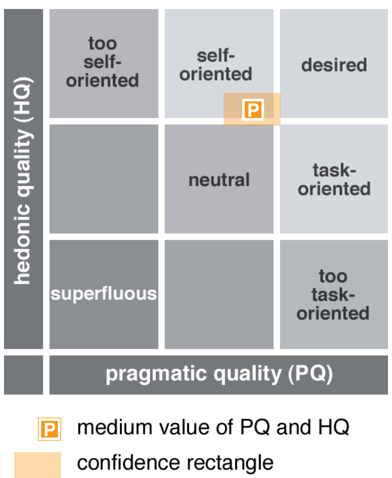

Figure 11. Average values of the dimensions PQ and HQ and the confidence rectangle for the MindMap prototype.

Initial Evaluation

Hedonic and pragmatic aspects of the *MindMap* prototype were evaluated in a short exploratory user evaluation. First, we wanted to see if the *MindMap* prototype is a relevant application for users in the context of the *SSI* concept. Second, we wanted to test some of the interaction techniques in terms of naturalness, ease of learning and use. The evaluation was conducted with 6 international students who had previously participated in the probes study and co-design sessions. The participants varied in gender (5 male, 1 female), age (between 24 and 26), and background (5 technical, 1 non-technical). The evaluations were conducted in 2 groups of 3 (Figure 10). All sessions were recorded on video.

Tasks

In the first part of the study (30 min.), we briefly explained the *MindMap* prototype and its interaction techniques. We then allowed them to freely explore the available functionality and get acquainted with the application. In the second part of the study (30 min.), all 3 participants collaboratively created a mind map containing at least 10 notes. We proposed some topics for discussion that had emerged in the co-design sessions (e.g. planning a night out, organizing a party). Otherwise, they could freely think of a new topic for the mind map. In the final part of the study (30 min.), we had semi-structured interviews in which we asked participants to walk us through some of their experiences while creating the mind map. We were also interested in obtaining feedback on the general principles behind the *SSI* concept. Finally, we asked participants to fill-out an AttrakDiff [4] questionnaire to quantitatively measure the hedonic and pragmatic aspects of the prototype.

Implementation

The prototype was implemented as a C++ application running on the Nokia N900 mobile computer. The three N900s used in the evaluation were communicating over WLAN and Bluetooth connections to share application state between each other in real time. The user interface was implemented on top of the Qt toolkit using OpenGL ES 2.0 for fluid animations and the flexibility needed for zooming, panning, and rotating the MindMap view. The devices were set on a small and tall square table (60x60x130cm). Participants were standing on three sides of the table. This setup allowed us to minimize orientation issues with the mind map.

Initial Findings

Regarding the ratings on the standardized AttrakDiff questionnaire (Figure 11), the prototype was rated as "fairly self-oriented". It was rated high on the hedonic quality (HQ), namely because it "stimulates users, awakes curiosity and motivates them" and "the overall impression of the product is very attractive." On the pragmatic quality (PQ), the results show "there is room for improvement in terms of usability." The confidence rectangle shows the level of agreement between users. Regarding our qualitative results, we built affinity diagrams for the analysis [6]. In general, participants were positive both on the *MindMap* prototype and the *SSI* concept. Participants thought the joint interactions required to build a mind map were new and stimulating. Users reacted to the prototype saying, *"it is innovative and interesting"*, and *"playful and interactive."* On the *SSI* platform, participants liked the idea of engaging in social co-located interactions by sharing their devices. They referred to the *SSI* idea as *being "very tempting", "great for multiplayer games"* and *"for any type of collaborative work."*

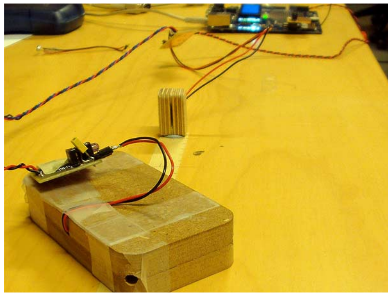

Figure 12. Ongoing work to track the position and orientation of devices on a table.

Conclusions and Future Directions

In this paper we introduce the *Social and Spatial Interactions* platform. The platform encourages people to engage in shared co-located interactions with their mobile phones. Based on four main design principles of the *SSI* platform, we have built and evaluated the *MindMap* prototype. The results of the initial evaluation are promising as the participants saw the potential behind the *SSI* platform and the *MindMap* prototype by giving positive comments, suggestions for improvement, and potential future areas for use and development.

In the future, we plan to further explore the spatial aspects of the interaction by adding position-tracking sensors to the devices used in the prototype. We are currently investigating the suitability of various tracking technologies (Figure 12). Once we are able to determine the positions of the devices in relation to each other, we can research new interaction techniques based on device proximity and orientation.

Further, we are interested in exploring the applicability of the *Social and Spatial Interactions* concept to various other applications beyond the *MindMap* application. These applications cover various physical and social contexts of use. For example, the platform could be used in a home context to share media content, or outdoors for sports and multiplayer games.

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