

Pass-Them-Around: Collaborative Use of Mobile Phones for Photo Sharing

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ABSTRACT

In this paper we explore shared collocated interactions with mobile phones. We introduce a phone-based application that allows a small group of collocated people to share photos using the metaphor of passing paper photos around. The prototype encourages people to share their devices and use them interchangeably while discussing photos face-to-face. The prototype supports *ad-hoc* photo sharing in different contexts by taking into account the spatial arrangement of users around a table, measured with sensors embedded in their mobile phones. Our evaluations show that people are willing to share and connect their mobile phones to engage in collaborative interactions. Participants were able to easily share their collections of photos using our proposed interaction techniques.

Author Keywords

Collocated Interaction, Handheld Devices, Photo Sharing.

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms

Design, Experimentation, Human Factors.

INTRODUCTION

Mobile phones were conceived to enable communication between remote participants. While some technologies and applications have been developed to support interactions between collocated users, in general mobile devices have provided little support for local interactions. Our Social and Spatial Interactions (SSI) platform [22] extends the use of mobile devices to support shared interactions between collocated users. In this platform, the users' personal mobile devices become elements of an interaction system that is shared between all users. A key technology enabling such interactions is the ability to track the positions of mobile devices related to each other and the environment.

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In the field of consumer photography, the adoption of digital imaging technologies has changed the way people see and understand photography: cheap digital cameras have become ubiquitous in our society, viewing and using photos instantly after capture has become possible, and the practically negligible cost of digital photos has lowered the barrier of photo capture [11]. Online services that support remotely sharing, distributing and commenting digital photos have emerged to challenge the traditional face-to-face sharing of paper photos. While these new sharing technologies offer many benefits over traditional methods, they lack the richness of social interaction when compared to sharing photos between collocated users [6,21].

We present the design and evaluation of the *pass-them-around* prototype, which allows a small group of collocated people to share photos. We have taken conventional sharing practices with paper photos as a starting point to see how technology could better support those practices. The evaluation of the prototype shows that people are willing to share and connect their mobile phones to engage in collaborative interactions. Participants easily shared their photo collections using our proposed interaction techniques.

The rest of this paper is structured as follows. First, we provide background information on the SSI platform and review relevant related work. Then, we describe the general design principles and interaction techniques of *pass-them-around*. Finally, we report the results of the evaluation, followed by discussion and conclusions.

BACKGROUND

Social and Spatial Interactions (SSI)

Mobile phones were originally conceived and have traditionally been utilized for personal use. The improvement in sensor and short-range communication technologies offers possibilities to explore shared use of mobile phones. In this paradigm shift, collocated users engage in collaborative activities using their devices, thus going from *personal-individual* towards *shared-multiuser* experiences and interactions. Our Social and Spatial Interactions (SSI) platform [22] extends the current individual use of these devices to support shared collocated interactions with mobile phones. The question the platform addresses is if people are willing to share their personal mobile devices and engage in collaborative interactions.

SSI Principles

The main principles of Social and Spatial Interactions are:

- *Social*: We support joint multiuser interactions by encouraging people to share their devices to reach a given goal. We have been looking into various physical and social contexts of use, e.g., office teamwork [23], sharing media content at home (this paper), and outdoor games.
- *Spatial*: We can use the relative positions of the phones with respect to each other on a flat surface to create interactions. We provide a tracking solution that is built in the phone [5], thus we do not require a dedicated infrastructure (i.e., fixed lab setting) or external equipment (e.g., infrared tower or camera) for tracking.
- *Tangible*: Tangible user interfaces (TUIs) allow people to interact with digital information by manipulating physical objects where the data is coupled with the object [17]. We explore the use of a mobile phone as a physical interface to manipulate data by performing simple actions (e.g., move, sort, group, join, spin, stack, etc.). Siftables [25] have inspired our SSI platform work.
- *Multimodal*: We use touch (i.e., touchscreen) and device gestures (i.e., gestures performed while holding a device in one's hand) as the two main user input modes. We provide multimodal feedback during the interaction, not only through visuals, but also through haptics and sound.

User-Centered Design Approach

We have been following a user-centered design (UCD) approach by involving end-users in the process of creating novel artifacts and interactions for the SSI platform. We have conducted a probes study, co-design sessions, and evaluations of prototypes. Taking these different steps has allowed us to gain a better understanding of how people might use the SSI technologies.

First, we conducted a probes study [12] with 14 mixed-nationality students where we observed people's pervasive use of (mobile) technologies. Participants reported things to us such as checking Facebook as the first thing they do in the morning (before brushing their teeth or taking a shower), or using their laptops while sharing the same table, constantly switching and transitioning between an individual and a social situation. Second, we invited five probe study participants to co-design sessions. We began each session by sharing and discussing findings from the probes with our participants to validate our results. We then presented a simple demonstrator showing the possibilities of SSI. After the demo, participants and three researchers engaged in brainstorming sessions. This work resulted in 20 possible SSI applications. Third, we took one of the 20 SSI applications and implemented it to demonstrate the potential of the SSI platform and some of its principles. The MindMap prototype [23] is a brainstorming tool that allows a workgroup to create, edit, and view virtual notes on any table. In this paper we introduce a second application from the SSI list: the *pass-them-around* prototype.

RELATED WORK

A large body of related work has influenced the design of the *pass-them-around* prototype. We have identified three main related-work areas: personal photography, collocated photo sharing, and collocated photo sharing applications.

Personal Photography

There is a rich literature on both conventional and digital personal photography and their associated practices. In the field of anthropology, Chalfen [6] studied conventional family photography and the role of photos in the home. The term Kodak Culture [6] refers to the old practice where consumers share printed photos or video footage of friends and family in a 'home mode' type of communication. Chalfen describes in detail the behavior of *storytelling* or using one's photos to tell stories *about* the pictures.

When consumers adopted digital cameras, the HCI community began a rich tradition of studying people's practices surrounding digital (and conventional) photos. Frohlich *et al.* [10] developed a set of requirements for 'Photoware' (i.e., technologies that support storing, sending and sharing photos) by studying what people do with conventional and digital photos once they have captured them. Besides the type of *storytelling* behavior reported by Chalfen, they found that people also engage in *reminiscing* talk around photos, especially when sharing photos with members who were present when the pictures were taken. Both types of behavior, *storytelling* and *reminiscing*, are what Frohlich *et al.* refer to as 'Photo-talk' [10]. Crabtree *et al.* [9] further elaborated on this work by developing requirements for distributed collaboration around digital photographs. To achieve this, they conducted a close examination of two empirical instances of conventional photo sharing. Miller and Edwards [26] looked at people from the Kodak Culture who had fully converted to digital photography to see how their practices have changed. They also studied people's digital photo sharing practices on Flickr. They found two types of practices: the Kodak Culture and 'Snaps' people. Compared to the former, 'Snaps' are less concerned with privacy, share photos outside their existing social networks, and concentrate on *taking* pictures instead of *sharing* them.

More recently, the use of cameraphones opened a new line of research for personal photography. With their prototype, Mäkelä *et al.* [24] first studied networked digital photography enabling photo sharing that was nearly synchronous with capture. They identified that people shifted from telling stories *about* the pictures, to telling stories *with* the pictures. Koskinen *et al.* [18] looked at another type of image sharing with cameraphones via MMS. Ames *et al.* [2] conducted a 5-month study of cameraphone photography and derived a list of requirements for mobile photoware.

In their studies, several authors have found that people still rely on the printed photo as a photo-sharing object [6,9,10].

Collocated Photo Sharing

Within the larger context of personal photography, some researchers have specifically looked into collocated photo sharing practices. Lindley *et al.* [20,21] studied how people share photos at home through different means such as with loose printed photos, photo albums, cameras connected to a TV and a remote control, PCs and laptops. She proposed a set of design guidelines for photo sharing using domestic display technologies. Based on four inter-related studies on collocated photo sharing, Van House [31] identified 11 forms of face-to-face sharing: prints, photo album, self-published photographic books, slideshows (35mm slides or LCD projectors), slideshows on laptops or larger screens, framed photos (at work and at home), desktop computers, laptops, cameras, cameraphones, and online (Flickr). Each of these forms of sharing has unique advantages and limitations. She also discusses four reasons for the continuing popularity of collocated photo sharing: 1) memory, storytelling and identity, 2) relationships, 3) orality, and 4) performance. Stelmaszewska *et al.* [30] studied collocated photo sharing using cameraphones, where both capturing and sharing are done through the mobile phones. They focused their work on understanding the role of the place where sharing occurs, how and when people share photos, what determines who the photos are shared with, and what influences their sharing experience.

Collocated Photo Sharing Applications

Souvenirs [28] supports photo sharing in settings provided by the domestic environment where face-to-face can naturally occur (e.g., living room or kitchen). It links objects to photos by assigning RFID tags to physical memorabilia found in the home. Using special software, people first create a folder of photos and then place an object on an RFID reader to associate the object with the photo set. The object is later placed on the RFID reader to trigger a slideshow on a large LCD screen, or for navigation using a special physical scroll wheel. Shoebox [4] combines (physical) storage and display for digital photos. Shoebox is a box with a display at one end that can be stacked on a shelf or brought down to show photos to others. Lifting the lid and running your finger through a touch-sensitive surface on the top of the device results in navigating photos.

Other photo sharing applications use mobile phones or other portable devices to share photos. StoryTrack [3] is a portable prototype that supports local sharing of photos. People hold the device with two hands and control the viewing of images using buttons mounted on the edges of the prototype. Up to two users can view images side by side and can also share control of the presentation. The device can be passed around like a regular photo album. Additionally, audio narrations can be recorded and later played back. Ah Kun *et al.* [1] propose a network of PDAs that allows any user of a group to broadcast images on the other devices in that group. Images are transferred wirelessly using Wi-Fi. Their prototype incorporates a

series of floor-control policies or software locks that determine who can control the show and when, in order to study how to best manage social interaction. Mobiphos [8] supports capturing and real-time sharing of photos among members of a collocated group using cameraphones. The application presents users with an updated stream of picture thumbnails made by the group. The display is used both as a viewfinder and a thumbnail gallery. Data is transferred between devices using Wi-Fi. Disc-O-Share [19] allows browsing and transferring photos between mobile phones (via Bluetooth) by creating three distal regions around mobile phones. Particular actions are triggered in response to entering or leaving these regions. An external camera tracks the position of the phones by reading visual markers displayed at the top of each device's screen. *Pass-them-around* differs from these applications in that it tries to emulate characteristics of sharing traditional paper photos to support a set of related practices (e.g., sequential sharing, huddling, etc.) by using the spatial arrangement of people.

DESIGN OF PASS-THEM-AROUND

Based on the findings from the SSI probes study and co-design sessions, and the relevant literature described in the previous section, we decided to design and implement the *pass-them-around* prototype that: 1) allows a small group of collocated people to share photos using the metaphor of passing printed photos around, 2) supports conventional photo sharing social practices, and 3) supports *ad-hoc* photo sharing by taking the spatial arrangement of people around a table into account.

Passing Printed Photos Metaphor (Tangibility)

The physicality of the paper photograph has important implications for photo sharing [20]. In the transition from paper to digital photographs, aspects such as the proximity of the photos to the group, access to control of the process of photo sharing, and how the group members are arranged in relation to one another have been lost. Lindley *et al.* [21] have found that people like having printed photos to hand and that being able to touch them facilitates involvement.

We use the metaphor of passing paper photos around to suggest interaction semantics. Each mobile phone device becomes a physical container of individual photos. In this way, photos regain their qualities as physical artifacts and their affordances for tangibility.

Conventional Photo Sharing Practices (Social)

The use of domestic display technologies has an impact on how people socially interact and experience collocated photo sharing [21]. It has been well documented that photo sharing is a social activity where seeing the reactions of others is an important part of showing photographs [6,21]. When viewing photos in front of a desktop computer or laptop, usually two people are seated in front of the screen (e.g., the audience) while a third person (e.g., the photographer) is *hovering* behind. As a result, it becomes

difficult for the photographer to see if the audience is enjoying the photos. Passing prints around also affords the formation of group huddles or *huddling*, which amplifies the closeness inherent in conventional photo sharing.

We support conventional photo sharing practices by allowing a group of four people to discuss pictures face-to-face. Each person can use their mobile phone individually or interchangeably, to create flexible interactions within the group. We support *photo pointing* to synchronize conversation and presentation [21], and *huddling* to browse and discuss photos together in smaller groups of people.

Flexible Interaction (Spatial)

As mentioned earlier, how people are arranged with respect to one another in a photo-sharing group is very important. Moreover, there are social areas at home (e.g., kitchen, living room) and outside (e.g., bar, café) that are better suited for photo sharing. For example, photos in the center of the living room become a focal point and the open seating arrangement allows people to see one another [21].

We support *ad-hoc* photo sharing using devices enhanced with radio tracking technology [5], which allows tracking the relative positions of the devices on a flat surface. The sensors embedded in the mobile phones allow us to know where people are seated (or standing) around the table. In this way, we are able to send images between individuals and generate sequential passing of images between the devices even when people change their positions around the table. As no extra hardware is needed besides the enhanced phones, photo sharing can take place in different contexts such as over drinks at a bar or in the living room at home.

INTERACTION

The idea behind our concept is to allow a small group of collocated people to first individually browse their collections of photos and then collectively share photos as a group on any table surface. Instead of taking established digital photo sharing practices as a starting point (e.g., duplicating images, automatic slideshow mode, etc.), we took an alternative approach. Based on the rich existing literature on photoware, we tried to replicate conventional photo sharing practices (e.g., passing paper photos around, face-to-face communication, huddling, etc.) and see how technology could better support those practices.

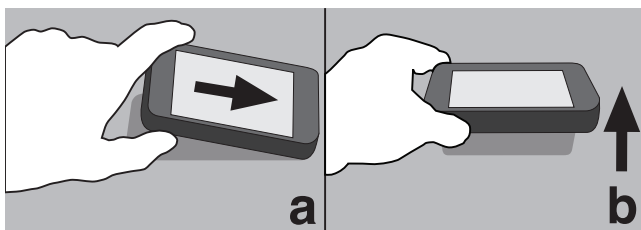


Figure 1. (a) Tilting horizontally to browse individual photo collections, and (b) tilting vertically towards the center of the table to start sharing a collection of photos.

Browsing Individual Collections

We propose a type of browsing that mimics individually flicking through a stack of paper photographs from one pile to another. After starting the application, users are presented with their individual photo collections as a pile of photos, thus the four devices display one pile each. To browse through the photos users must tilt their devices horizontally by performing a quick upward movement on either side of the device (Figure 1a) and bringing it back to a rest on the table. As a result, the photo at the top of the pile slides in the direction the device was tilted revealing the next photo in the pile. When the end of the collection is reached browsing overshoots, reverses direction and stops at the last photo. Keeping the device tilted, results in a continuous and faster browsing. Cho *et al.* [7] proposed a similar tilt user interface where the amount of browsing is proportional to the tilt angle. As an alternative, users can tap either half of the touchscreen to browse photos, which triggers a similar animation as described above for tilting.

Sharing Individual Photos (*Throwing*)

Pass-them-around supports different ways of sharing pictures. The first one is similar to passing a paper photo to another person, regardless of that person's location. This type of sharing allows for flexible one-to-one sharing of images, one at a time. To share a photo, users must first select an image by either tilting horizontally or tapping, and perform a long press on that photo. A thumbnail of the image is displayed under the user's finger, which can be moved around by dragging the finger on the touchscreen. The photo can then be thrown in any direction by flicking the thumbnail. The devices are fitted with the necessary wireless sensors to detect their current location. If no device is found in the direction the image was thrown, then the photo briefly shakes back and forth on the sender's device. However, if another device is located in the direction the photo is thrown, the photo is shown on the receiving device. The new photo fills up the screen and is displayed on top of any other existing photo. An animation shows the direction where the new photo is coming from. When the image arrives, a subtle vibration is triggered every 4 seconds to cue the receiver to flick the image back to the sender. *Throwing* takes existing multi-display reaching techniques [27], and brings them into photo sharing on mobile phones.

Sharing a Collection (*Sequential*)

The second method allows sharing photo collections as a group, closely resembling the activity of passing paper photographs around one by one, in a sequence. To start sharing a collection of photos, its owner or photographer must tilt the device vertically towards the center of the table (Figure 1b). This movement replicates the gesture for giving something out to another person. As the screen is no longer visible to the photographer when the device gesture is performed, a single intense vibration is triggered to provide feedback. When the photographer successfully shares their collection of photos with the rest of the users,

the photographer's device shows the first photo of the collection, while the other devices show an empty corkboard texture. An animation showing how the three remaining devices that belong to the audience are emptied provides additional feedback to the photographer.

As previously mentioned, each mobile phone becomes a physical container of individual photos. Using horizontal tilt or tap, photos are then passed on one by one to the next person, in order. As we are able to detect the location of the devices, the photo is displayed on the next available device, even if people decide to switch positions around the table.

To investigate different social practices during photo sharing, we decided to incorporate different rules for control during browsing. For example, during *sequential* browsing the photographer decides the direction and the speed at which the photos are browsed. However, when the photographer passes their last picture around the table, then each audience member must decide when they want to pass it to the next person. In the case of passing the last photo around the table, each audience member decides the speed of browsing. These simple rules allowed us to study people's perceptions on who decides the speed of browsing.

During *sequential* photo sharing, audience members may want to inquire specific aspects of a given photo, other than the one the photographer is currently presenting. *Photo pointing* allows coordinating conversation and presentation. The audience can trigger *photo pointing* by performing a long press on a photo, which creates a copy of that photo on the remaining devices. The same user must again do a long press on the photo to stop *photo pointing* and resume *sequential* photo sharing.

Creating group huddles to closely discuss photos is a common practice in conventional photo sharing. *Pass-them-around* supports *huddling* by allowing smaller groups of people to view and discuss photos together. To connect two or more devices together, users must perform a pinch gesture on the screens of two devices (Figure 2a) [23]. Alternative ways of connecting devices include: knocking devices together to detect synchronized sounds [29], bumping devices together using accelerometer data [14], and performing pen gestures on touch-enabled devices [15].

When the devices are successfully tiled together, they display a composite larger version of the photo. By means of an animation, the current content is first removed from the devices showing the corkboard underneath, and then the new larger image slides into place. Additionally, pieces of masking tape indicate which devices have been tiled together and a distinctive scotch tape sound is played. *Sequential* photo sharing continues by considering the huddle as one physical photo container. It is also possible to tile three devices together (Figure 3). To achieve this, it is first necessary to tile two devices together for a 2x1 configuration, and then a third device can be tiled onto the existing huddle for a 3x1 configuration.

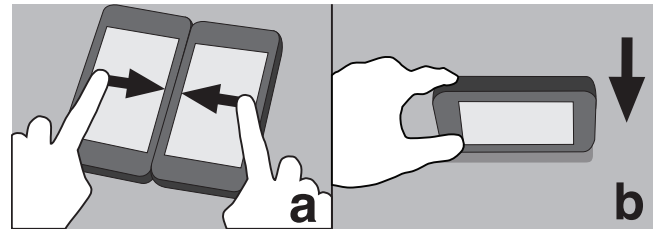


Figure 2. (a) Pinching two devices to create group huddles, and (b) tilting vertically towards oneself to stop sharing.

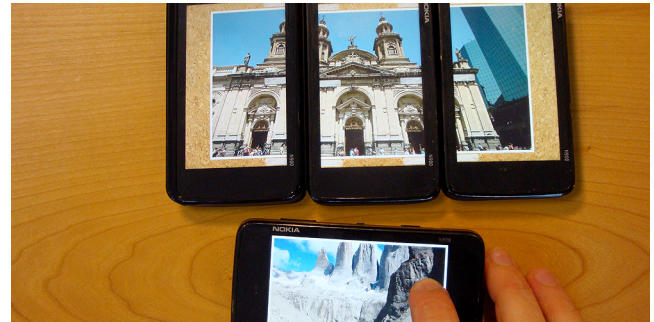


Figure 3. Three tiled devices during *sequential* photo share with one device acting as a controller.

Users can disconnect the devices from the shared view by simply picking them up from the table and holding them in their hands. This results in showing an overview of the corkboard. When the device is put back on the table, it resumes *sequential* sharing as an additional photo container.

To stop sharing a collection, the photographer must tilt the device vertically towards him or herself (Figure 2b). The device gesture is naturally associated to withdrawing an invitation or hiding something. A single intense vibration is triggered to signal that sharing has now stopped. The photographer can also directly obtain information on the new status of the prototype as the audience goes back to individually browsing their own collections of photos.

Sharing a Collection on a Single Display (All Tiled)

The third main method for sharing collections of photos consists of using all four devices to create a single larger tiled display. To connect four devices together, the users must first create two huddles of 2x1 devices. Then, these two huddles can be pinched together into a larger 2x2 configuration. The photographer's device is used to browse through the photos by tapping on either half of the screen.

EVALUATION

There were three main goals of the study. First, we wanted to test the ideas behind SSI and see if *pass-them-around* is a relevant prototype in the context of the SSI platform. Our second goal was to investigate the different photo-sharing strategies and social behaviors supported by the prototype. Third, we wanted to assess the proposed interaction techniques in terms of naturalness, ease of learning and use. To achieve this, we invited existing groups of friends to share their personal photos in a collocated way using the

prototype. We collected qualitative data both during the photo-sharing sessions and later during semi-structured interviews. Quantitative data was collected by means of a validated questionnaire after a photo-sharing task.

Participants

The evaluation was conducted with five groups of four friends, for a total of 20 participants. We recruited groups of friends, rather than isolated individuals, so participants would feel comfortable both with one another and with the photo-sharing situation. The participants were chosen to represent a variety of user types, including parents, international students who had previously participated in the probes study and co-design sessions, and professionals. The participants varied in gender (16 male, 4 female), age (between 21 and 40), and background (14 technical, 6 non-technical). All participants owned a mobile phone, different from the one used in the study. All participants were prior digital camera and/or cameraphone owners, and five participants also had digital SLR cameras. All participants had engaged in photo sharing activities via online photo sharing sites such as Flickr or Facebook by both posting and viewing online photos.

Method

We used participants' personal photos during the evaluation so they would have a real motivation to talk about and share those photos. Each participant brought in 15 digital photos, some taken when all four friends were present (for *reminiscing* talk), and others when only the photographer was present (for *storytelling*). All the photos brought by the participants were preloaded into all four devices to avoid long transfer times while sharing photos. Each participant was provided with one device running the prototype.

Each session consisted of four parts: introduction, exploration, task, and semi-structured interview. First, we gathered participants' background information about photography and photo sharing and asked them to recall one recent occasion in which they had shared photos with families and/or friends (15 min.). Second, we briefly explained participants how to interact with the *pass-them-around* prototype. We then allowed them to freely explore the available functionality and get acquainted with the application (15 min.). Third, all four participants took turns in sharing their personal pictures with each other (30 min.). At the end of the task, we asked participants to fill-out the AttrakDiff [13] questionnaire to quantitatively measure pragmatic and hedonic aspects of the prototype. AttrakDiff measures the attractiveness of interactive products along four dimensions. Pragmatic quality (PQ) refers to the product's ability to support the achievement of behavioral goals (i.e., usability). Hedonic quality refers to the users' self: *stimulation* (HQ-S) is the product's ability to stimulate and enable personal growth (i.e., personal goals and aspirations), and *identification* (HQ-I), is the product's ability to address the need of expressing one's self through

objects one owns (i.e., social aspects of product ownership). Both HQ-S and HQ-I have been found to contribute to perceived attractiveness (ATT), which describes a global value of the product based on the quality perception. Participants indicate their perception of the product by rating 28 pairs of opposite adjectives that relate to the four dimensions on a 7-point scale (-3 to 3). Finally, we had semi-structured interviews in which we asked a consistent set of open-ended questions to each group, prompting participants to walk us through some of their experiences while sharing photos using the prototype (60 min.).



Figure 4. Evaluation setup with four participants sharing photos using the devices on the round table.

The five sessions were conducted in an open meeting room area with modern and colorful furniture (Figure 4). This created the kind of cozy environment found in a bar, café, or living room. The four devices were set on a small and tall round table (60 cm. diameter x 130 cm. tall), and participants stood around the table. All sessions including the semi-structured interviews were recorded on video and transcribed. Participants were given one movie ticket each to compensate them for their time.

Affinity diagramming [16] was used to analyze the data from both the observations of use and the semi-structured interviews. Two researchers independently made notes as they watched the videos for each of the five sessions. The same two researchers collaboratively analyzed the qualitative data through several interpretation rounds. The affinity diagram supported categorization and visualization of the main themes emerging from the data. These themes form the heart of our findings section.

Implementation

We implemented *pass-them-around* on Nokia N900 mobile devices running the Maemo Linux operating system. The prototype was implemented in C++ on top of the Qt 4.6 software framework with optional OpenGL ES 2.0 rendering used for user interface graphics. Using OpenGL allowed applying fluid animations for moving, rotating and zooming the photos. In order to display events across different devices, the devices' clocks were synchronized.

As the application was running on several devices in a distributed manner, we needed to share coordination information about the application state and user actions between the devices. This was accomplished by setting up a

wireless personal area network, onto which all the devices were connected. A Wi-Fi network was used on which messages sent by one device were automatically transmitted to all other devices. The devices were able to detect each other's presence with broadcast UDP packets.

The N900's internal accelerometer was used to detect when a device was picked up from the table, or when it was tilted. When the sensor showed a constant pull toward the back of the device, it was deduced that the device was on the table. When there was a constant and distinguishable pull in a given direction, it was recognized as a tilt. In all other cases, the device was considered to be in the user's hands. To simplify the device gestures, tilting vertically towards oneself was considered the same as picking up the device.

To detect people's positions around the table (e.g., to flick a photo to another device), we utilized N900 devices enhanced with radio tracking technology [5]. This particular technology tracks the angular position and distance between devices by embedding multi-antenna receivers under the devices' screen and running sensor array signal processing algorithms on each device. This allows the technology to track multiple emitters such as active RF tags or mobile phones. This radio tracking technology was conceived to track longer distances, thus the accuracy for sensing device proximity was one meter. More accurate distance measurements could for instance be used to automatically tile devices when put next to each other.

FINDINGS

In the following sections we describe the main findings from the *pass-them-around* evaluation. First, we briefly describe how participants currently share photos with family and friends. Second, we present a description of different photo-sharing practices that our findings suggest. Third, we examine people's natural social interaction during face-to-face photo sharing. Finally, we look at different aspects of spontaneous photo sharing.

Current Photo Sharing Practices

Our study confirms prior findings in photo sharing practices. Most participants reported using online services (e.g., Flickr, Picasa, Facebook) to share photos [31]. They receive feedback on the photos either through comments posted directly on the service, by chatting online, or over the phone. Other ways of sharing photos include [20,21,31]: directly showing photos from their laptop (7/20) or digital camera (4/20), connecting a digital camera, camcorder or cameraphone to a TV (4/20), using a mobile phone by either passing it around and showing photos from the display or by sending an MMS (4/20), and sending photos as email attachments (2/20). Participants said they would only order prints or print photographs to send them abroad to family members who did not have access to the technology, to frame them and hang them on the wall, and to put them in photo albums for later browsing: *"Very rarely we do this exchange of pictures on paper."* [P2]

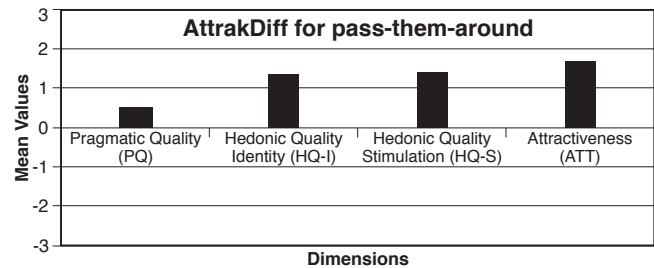


Figure 5. Mean Values along the four AttrakDiff dimensions.

Different Photo Sharing Strategies

Sequential Photo Sharing

Participants used different strategies to share photos as a group. First, participants tried *sequential* photo sharing. All participants were able to both share their collections by tilting their device vertically and browse through the photos by tilting the device horizontally, describing the gestures as *"natural."* Most participants (16/20) said that tilting horizontally for browsing was intuitive for them: *"Is tilting meant to emulate sharing printed pictures? For me tilting was nice, it was like passing a paper picture."* [P18] On the AttrakDiff questionnaire (Figure 5), the value for the attractiveness (ATT) of the prototype is located in the above-average region and thus the overall impression of the product is very attractive. The high ratings on this dimension confirm that participants thought the prototype was motivating and appealing.

About half of the participants had some trouble following the discussion of photos that were not currently displayed on their devices: *"The picture on my screen is not interesting because I am not hearing the comments about it. (...) You see the picture that was commented three pictures ago."* [P12] Participants frequently used *photo pointing* to partially solve this problem as it allowed coordinating conversation and presentation of the photos.

Photo pointing was naturally used when the photographer or the audience thought that the content was interesting. Since with *photo pointing* all participants are looking at the same photo, they tended to focus on their own devices and make comments. This was natural as in this situation there is no need to maintain the joint attention in other ways. Few participants (4/20) picked the phone up to have a closer view of the current photo. Unfortunately, in the current implementation this resulted in showing an overview of the corkboard where people can see who is connected and what is currently being displayed on their devices. This overview mode was seldom used during the evaluation: *"The overview is kind of useless."* [P11]

To our surprise, participants developed a new sharing strategy out of this need to simultaneously see the same photo that the photographer was explaining. As the photographer was unable to trigger *photo pointing*, they would pass a picture to the next participant and ask them to perform *photo pointing* instead. This allowed the

photographer to remain in control of the presentation while everybody was looking at the same photo. When the photographer was done explaining a photo, they would ask the same participant to stop *photo pointing*. We call this new emerging way of photo sharing *mirrored view*.

Photo Sharing in Group Huddles

While involved in *sequential* photo sharing, participants also created *group huddles* in all sessions. All participants were able to successfully tile displays together by performing the pinch gesture. Almost all participants (19/20) thought the gesture was natural. Two participants explored new ways to pinch devices together by doing a reverse pinch (from the center towards the edges), and by trying to connect three devices with one pinch.

When a *group huddle* was created, a few photographers complained about having a different picture on their device than the one currently shown on the tiled display. The effect was more noticeable when all audience members formed a *group huddle* (3x1): “How can I explain when I have one picture on my device and another on the (tiled) 3x1 device?” [P6] In that case, the photographer’s device is mostly used to control, so that one person is presenting and the others are watching. Regarding tiling configurations, 3x1 was used the most followed by 2x1x1 (i.e., two tiled and two individual), while two *huddles* of 2x1 devices was only used in the build up to the *all tiled* configuration.

Photo Sharing With All the Devices Tiled

Participants used the *all tiled* configuration in most sessions. Although most participants (19/20) were able to perform the sequence required to create the *all tiled* display, one participant said it required too many different steps: “Getting (all tiled) had to be done in a specific sequence which is a bit counterintuitive.” [P12] Some participants (7/20) did not like how images were partitioned by the bezels when tiling. They proposed having the possibility to pan and zoom into the image as an alternative: “Due to the breaking of the picture you may miss something.” [P7]

Other Ways to Share Photos

Finally, some participants (6/20) requested more flexible ways of sharing photos such as random sharing and being able to look at a specific photo while the others can continue sharing at their own pace: “It would be nice to (...) pass a photo to two people but not to a third.” [P10]

Supporting Natural Social Interaction

In general, participants said the prototype supported natural social interaction by means of immediate verbal and non-verbal feedback. Participants used different strategies to explain the content and context of the photos to one another. The photographer usually told stories about each of the photographs and the other participants asked questions, made comments, and used gestures to point at interesting photos or parts of the photos. *Photo pointing* was often used

to focus the discussion on a single photo: “It is really nice that (here) you can pass some pictures, comment at the same time, and point out things.” [P12] Some participants expressed that the proposed type of collocated photo sharing was preferred over sharing photos online due to the lack of immediate feedback in the latter. When sharing photos online, participants use synchronous communication means such as chat or phone to get feedback: “Explaining photos on Facebook is like giving a speech and you don’t know how the audience in front of you feels.” [P4] On the two hedonic quality dimensions of AttrakDiff, i.e., identity (HQ-I) and stimulation (HQ-S), the prototype is located in the above-average region implying that people think the prototype is connective and captivating. These ratings confirm the participants’ preference for sharing photos in a face-to-face situation with the help of the prototype.

As previously mentioned, we incorporated different rules for control during browsing to investigate photo sharing social practices. During *sequential* sharing, participants felt it was natural for the photographer to be in control when sharing their images by deciding the direction and speed of browsing. However, giving away the control when passing the last photo created confusion for some users (8/20). *Photo pointing* and *throwing* created similar confusion. The audience member that triggered *photo pointing* had to remember to stop it afterwards, and the recipient of a *thrown* image had to return the photo. These rules acted as social interaction inhibitors that blocked group interaction. On the AttrakDiff questionnaire (Figure 5), the prototype was only rated as average on the pragmatic quality (PQ) dimension, which means that there is room for improvement in terms of usability. These rules may have impacted the ratings on this dimension. Participants used each other’s devices during the interaction regardless of its owner, apparently perceiving the prototype as one entity.

Supporting Spontaneous Photo Sharing

About half of the participants (9/20) explicitly said that the prototype allowed them to share photos spontaneously. Participants saw the potential of using the prototype in different contexts. Mobile phones and laptop computers were currently being used to show photos from their displays. While people said they carried their mobile phones with them everywhere, not all took their laptop to more informal settings such as a café or a bar: “It is interesting as you do not carry your laptop all the time but you have the phone with you.” [P7] A few participants (5/20) said they would prefer holding the device in their hands while sharing photos rather than keeping it on a table. As an example, participants mentioned sharing while sitting on a sofa: “It would feel more natural to hold the mobile phone in your hand than holding it on the table.” [P14]

Participants said the use of the spatial arrangement of people around a table allowed them to easily share photos. *Throwing* was an intuitive gesture to share photos, especially when sending a photo across the table to a

specific person: “*I think it is a cool feature to just look at a person and just send the photo (makes a sweeping gesture).*” [P14] The different orientations of photos with respect to the viewers could potentially have been a problem, especially for the tiled configurations. However, most participants flexibly used the different tiled configurations regardless of the orientation. In some cases the photographer would see the tiled device in the right orientation, and in others it was the audience. In other cases participants would move closer to the photographer. When viewing individual photos in landscape and portrait orientations on their devices, participants would either rotate their heads, or rotate the devices, or not mind at all.

DISCUSSION

Sharing One’s Own Device

The main question we were trying to answer is whether people are willing to share their devices and engage in collaborative interactions. The data collected in the *pass-them-around* evaluation shows that people were positive about sharing and connecting their devices to create a common interaction space. Participants gave similar feedback in the previous MindMap evaluation [23]. However, we are unable to fully answer this question at this point because in the evaluation participants were not using their personal devices, but the modified N900s we provided them with instead. In spite of this, there were lively discussions on using their actual devices for collaborative interactions. Some participants expressed their concerns regarding letting other people handle their phone as they may spill drinks over the phone when using it in the context of a bar or café, or unintentionally damage (i.e., scratch the backside when moving the phone on a surface), beyond the normal wear and tear that happens from daily use. However, most participants felt the benefit of engaging in *ad-hoc* collocated social interactions using the phones outweighed the potential risk of damaging the device.

Using Different Devices

Together with establishing that people are willing to share their devices, comes the fact that people have different types of mobile phones. Some participants (6/20) wondered how compatibility issues would affect collaborative interactions. The main concerns were related to different form factors, screen types and underlying technologies. First, differences in form factors between different phone models could make joint interactions such as tiling difficult, cumbersome, or even obstructive. Second, using touchless devices would require different interaction mechanisms (e.g., bumping to tile displays), which may diminish the intuitiveness of gesture-based interactions. Finally, using different touch technologies during pinching would require applying different pressure on each device: a hard touch on a resistive screen and a lighter touch on a capacitive screen. Hence, the platform would need similar device form factors and underlying technologies to be easy and intuitive to use.

Privacy Concerns

When discussing about sharing photos (or other media content) in a public environment, our participants raised their concerns on privacy. Half of the participants wanted to be able to control who they are sharing photos with and be aware of other people nearby who may be trying to join the sharing session. Having this type of control would prevent accidentally *throwing* a photo to a stranger when sharing would take place in a bar or park. The ownership of the content shared in a session was also discussed. Participants were evenly divided between those who thought the photos should only be temporarily displayed on the devices, and those who said the photos should be permanently transferred to all members of the sharing session.

Interaction Techniques

In the evaluation, participants suggested using the proposed gestures beyond the hard table surface. When seated on a couch, it is indeed more natural to share photos by taking the device in their hands. The table surface makes it easier to recognize the tilt gestures by providing a reference point. However, it is still possible to make all the gestures if people are holding their device in their hands (e.g., standing or seated next to each other), although the gestures become then harder to detect. The proposed gestures could also be used in different applications and domains. For instance, the pinch gesture could be extended to connect not only between mobile phones, but also to form a larger device ecosystem, which would include smaller jewelry-sized touch-enabled devices and larger tablet devices. The vertical tilt gesture (away from and towards oneself) could be used as a generic way to define the intention to: join and leave a session; start and stop sharing; reveal and hide something; and take or relinquish control of a situation. Finally, for our next prototype, we will be exploring the use of the *throwing* gesture in a bar context to share content between a mobile device and several public displays.

CONCLUSION

The Social and Spatial Interactions (SSI) platform explores shared collocated interactions with mobile phones. In the context of SSI, we have introduced the *pass-them-around* prototype, which allows a small group of collocated people to share photos. The prototype encourages people to share the devices and use them interchangeably while discussing photos face-to-face. We proposed different ways of sharing photos based on the metaphor of passing paper photos around. Using devices fitted with the necessary wireless sensors to detect their current location, participants were able to pass photos sequentially around the table. Additionally, the sensors allowed participants to flexibly share photos directly to another person. Evaluations with five groups of four users showed that people would be willing to share and connect their mobile phones to engage in collaborative interactions, although the idea of the SSI platform raised some concerns regarding wear and tear, compatibility and privacy. Regarding our prototype,

participants were able to easily and flexibly share their collections of photos using our interaction techniques.

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