

Mobiphos: A Collocated–Synchronous Mobile Photo Sharing Application

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ABSTRACT

People use photographs for numerous reasons with one of the most common uses of both analog and digital photographs is as an artifact to share and discuss with others. While the practice of photo sharing has been thoroughly examined in the HCI community, there is currently very little research on easily capturing and sharing content within groups of collocated mobile users. In this paper we present the design, implementation, and evaluation of a *mobile photo sharing* application, Mobiphos, that gives a group of collocated users the ability to capture and simultaneously share photos in real-time with each other.

Categories and Subject Descriptors: H.5.3 [Group and Organization Interfaces]: [Synchronous interaction, Collaborative computing]

General Terms: Human Factors

Keywords: mobile, photo sharing, collocated

1. INTRODUCTION

Ever since the first commercially-available cameras were introduced in the late 19th century, photographs have been inherently social artifacts. Photographs are captured and shared in social contexts. When one engages with photography, one does so in a particular cultural context, reflecting socially-constructed norms about what one photographs or what one says about those photographs [7].

Computational innovations in the 20th century such as digital cameras and camera phones have dramatically influenced the ways by which photographs are taken. Further, networking innovations have influenced the methods by which photographs are shared. Mobile multimedia messaging services (MMS) for camera phones and web-based photo sharing sites such as Flickr have enabled many new photo sharing practices.

Historically, the acts of capturing and sharing photographs have been carried out asynchronously, with sharing occurring some period of time after the photographs have been taken. The goal of our research is to explore the impact of mobile technologies that

alter this traditional relationship. In particular, we are interested in examining the impact of the collocated–synchronous capture and sharing of photographs on the experiences of small, social groups.

These shared experiences might be those of family members at a family reunion or of a group of friends at a party on a Friday night. These shared experiences might also include groups of family, friends, or even recent acquaintances traveling and visiting a new city, a genre of photography Chalfen has called “Camera Recreation” [7]. For example, consider a group of tourists taking pictures as they share in the experience of exploring a new city. Certain landmarks may be so iconic that every recreational photographer in the group will want pictures of them. Yet, each recreational photographer will also likely have different interests and perspectives when taking pictures and, as such, may take unique photographs, as well. Some group members may take photographs of other group members and those other group members may take their photograph in return. In the end, it is highly likely that group members will want to see or even have copies of photographs taken by other members of the group—photos reflecting multiple visual accounts of the shared experience.

In this paper we present a novel *mobile photo sharing* application, Mobiphos, designed to support collocated–synchronous photo capture and sharing. Mobiphos gives a group of collocated users the ability to capture and share photos synchronously with each other. As individuals in the group capture images, the software automatically copies the photographs to the rest of the group’s Mobiphos devices over a wireless network for sharing.

The contributions of this research are three-fold:

1. The identification of collocated–synchronous photo capture and sharing as a significant under-explored domain of digital photography and network visual communication.
2. The design and implementation of a novel photo capture and sharing application, designed to support collocated–synchronous photographic practices including novel interface designs to ameliorate the design challenges involved in the simultaneous capture and review of photographs on a single device.
3. The study and analysis of collocated–synchronous photographic practices and the identification of themes of use including practices that emerged to support the creation of a shared photo archive and in response to the situated nature of both the capture and sharing of photographs, reflections on the intersection of individual and group photographic practices, rhythms of use, interpretations of the system as both collaborative and competitive, and the relationship between identity and gift-giving.

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2. RELATED WORK

The anthropological and sociological literature surrounding photography has explored both the capture and sharing of photographs, unpacking them, for example, in the context of the Kodak Culture [7] or the cult of seasonal conformists [6]. Becker has challenged the assumption that the capture (or production) and sharing (or consumption) of photographs represented completely distinct sets of practices [4]. He argued that consumer–producer relationships are much more collaborative and that practices surrounding the consumption and production of photographs are reflexively influential.

While all capture and sharing occurs asynchronously with analog photography, the sharing of digital and analog photographs can either be collocated or distributed¹. The face-to-face sharing of photographs is well-studied in the literature with much research focusing on the conversations and storytelling surrounding that sharing [2, 7, 10, 11]. Photographs generated from analog photography can be printed and mailed to distributed recipients, but the breadth of ways that distributed photo sharing can occur has been greatly enhanced by recent computational innovations. Digital photos can also be printed and mailed like their analog counterparts. However, digital photographs can also be emailed or stored online for others to see. Various online venues supporting asynchronous, distributed photo sharing have also gained much traction (*e.g.*, Flickr [24], blogs [25], or other online photo sharing communities [23]).

In addition to fostering a large breadth of venues supporting asynchronous, distributed photo sharing, computational technologies have enabled photo sharing that is nearly synchronous with its corresponding photo capture. Much research in the last decade has explored this class of photo sharing. As early as 2000, researchers were exploring the increased sociability afforded by networked digital photography [21]. Vaida *et al.* explored synchronous, distributed photo sharing in the context of instant messaging [30]. The advent of camera phones and multimedia messaging enabled widespread, distributed, near-synchronous photo sharing and has spurred the largest research effort in this area [3, 13, 17, 19]. While multimedia messaging has become the *de facto* standard for transmitting media among mobile phones, it can be expensive and is not particularly conducive to sharing multiple media objects within groups of users.

Because of these and other limitations of multimedia messaging, several researchers have explored new technologies designed specifically to support near-synchronous, distributed photographic activity among groups. Counts and Fellheimer developed a mobile and web-based version of a photo sharing system for buddy-list-based groups [9]. Researchers from the Helsinki Institute for Information Technology have explored mobile technologies supporting group awareness and meaning making through a series of studies of photo sharing technologies between physically distributed groups of users attending large-scale events [14, 26, 27].

While technologies supporting the distributed sharing of near-synchronously captured photographs are receiving a significant amount of research attention, much less research has been conducted on the *collocated* sharing of near-synchronously captured photographs [1]. This particular time–space relationship among

photographic capture and sharing is a particularly important one, as well. Kindberg *et al.* studied the use of camera phones, exploring the breadth of ways that camera phone photos were shared, including but not limited to multimedia messaging, and found that the majority of photo sharing actually occurred utilizing the camera phone display in collocated contexts:

There was little evidence of a strong ‘capture and send’ culture... the study data showed that two thirds of the images examined were captured to share... The majority of image-sharing (one third of all images) took place face-to-face on the phone itself, often in the moment... [In addition] sharing involved impromptu storytelling, passing the phone to someone else, or swapping phones with a friend [17].

One research endeavor that has explored this important collocated–synchronous class of the capture and sharing of photographs explored a technique termed “synchronized shutters” which focused on the action of synchronized capture [18]. With synchronized shutters, each camera in a group was triggered to take a picture at the same time. This research focused, in particular, on issues associated with forming ad-hoc groups of strangers at a shared event. Kun *et al.* examined synchronized sharing of photos, specifically examining the issues of turn-taking and control in conversations [20].

Although the research of Kindberg *et al.* [17] found that the collocated–synchronous capture and sharing of photographs is key to the mobile and social use of camera phones, there has been a dearth of research in this area. Building on the research emphasis of a few notable exceptions [18, 20], we contribute a novel system design aimed squarely at understanding the mobile and social use of collocated–synchronous photography, focusing our attention on the unexplored area of the *in situ* use of this class of systems on the photographic experiences of existing social groups.

3. MOBIPHOS APPLICATION

Mobiphos is an application designed to run on digital cameras that supports the automatic sharing of photographs among members of a collocated group who are engaged in a social activity. Mobiphos allows users to easily take pictures, browse thumbnails of those pictures and share their photos within a collocated group of people in real-time. When a person takes a photograph using Mobiphos, that picture is automatically shared with every member of the collocated group. At the same time, she is able to view a constantly updating stream of picture thumbnails scrolling across her screen as they are being captured and shared with her by her fellow group members. From the user’s perspective, all of the photographs captured by the group form a common repository of images whereby each member of the collocated group has access to all of the photos.

The application is composed of several components. First, it serves as a simple digital camera program. It allows the user to press a button on the device which in turn triggers the capture of an image from the camera sensor. The images are compressed and saved to flash memory. Mobiphos also provides a digital viewfinder and thumbnail browser. Unlike traditional digital cameras, Mobiphos uses a network to provide its real-time photo sharing capabilities. Each image captured is shared with all other Mobiphos devices by sending it over a group-wide wireless network. Additionally, the user interface has been designed to facilitate and reinforce the shared nature of all of the photos captured by the collocated group.

¹The matrix of synchronous–asynchronous, collocated–distributed capture and sharing presented here is adapted from Johansen [15] and Frohlich *et al.* [11]. In contrast to Frohlich *et al.*, we employ the synchronous–asynchronous dimension to characterize the time-based relationship between capture and sharing as opposed to the time-based relationship between when the photos are shared and when those shared photos are viewed.

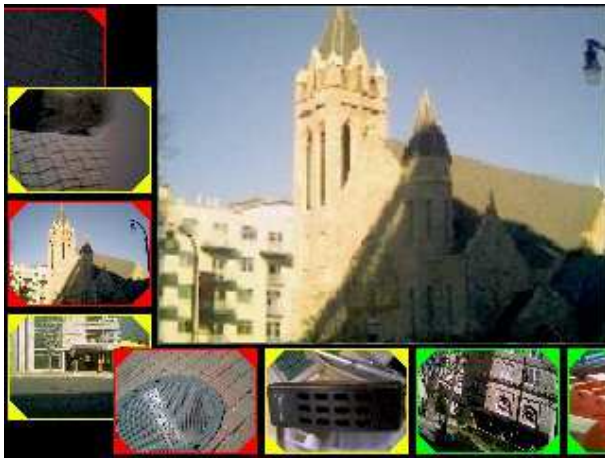


Figure 1: A screenshot of the Mobiphos interface with the thumbnail timeline in mid-animation. The viewfinder is in the top-right and thumbnails are along the left and bottom of the display. The colored border on the images indicates who captured the photograph.

Due to the real-time sharing nature of Mobiphos, there are several interaction challenges that must be overcome. Traditional digital cameras use the LCD screen for multiple purposes. During image capture it serves as a digital viewfinder showing the user the image they are about to capture. The LCD can also be used to browse images and thumbnails of photographs already captured. In Mobiphos, we need to combine these two modes into one to allow the user to simultaneously take new photos using the digital viewfinder as well as review photos being shared.

Our design uses the top-right, $\frac{3}{4}$ of the screen as the viewfinder while the remaining area of the display to the left and bottom of the viewfinder shows thumbnails in a timeline (Figures 1 and 2). The timeline positions the most recent picture in the top-left corner with the rest of the thumbnails oriented in an L-shape around the viewfinder from newest to oldest. This design allows the user both to take new pictures and view older photographs at the same time.

When a new photograph is captured by the user, or a photo comes from another camera running Mobiphos, the thumbnails on the left move down as the thumbnails along the bottom move to the right (Figure 2). This process clears a space in the top-left corner of the display to hold the thumbnail of the newly captured photo. As new pictures enter the thumbnail timeline from the top-left, older thumbnails leave through the bottom-right. In both cases, animation is employed to help the user better understand the state of the system. If the new thumbnail is coming from a picture taken by the user then the captured picture scales down from its original place in the viewfinder to the top-left thumbnail slot. Additionally, this thumbnail also receives an overlay, drawn like a picture frame, with a color specific to the user who captured the photo. If the new picture comes from another user, a thumbnail slides in from off screen to the top-left position to signify that it was not a picture taken by the user holding the camera.

Each thumbnail is $\frac{1}{16}$ of the total screen size allowing us to place seven thumbnails onto the display along with the viewfinder (Figure 2). Three thumbnails are positioned to the left of the viewfinder, one in the bottom-left corner and three below the viewfinder.

The user can navigate the thumbnail timeline by using the directional keypad on the device. Again we employ animation to

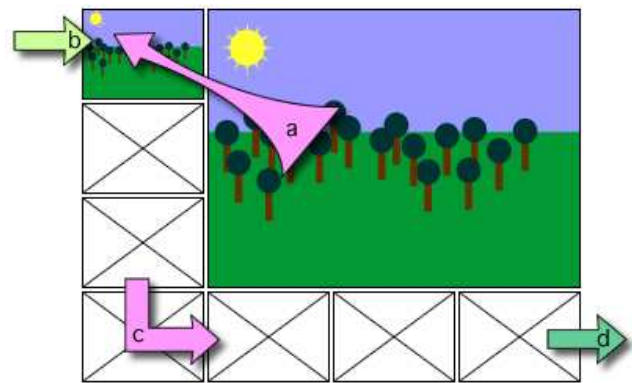


Figure 2: The viewfinder is represented in the top-right of the display. When the user takes an image, the picture from the viewfinder animates into the top-left corner (a). When an image comes from another user, it is also placed in the top-left (b). Either of these events cause the timeline to animate wrapping around the bottom-left corner (c) and the oldest image is moved off screen (d).

help the user understand how she is navigating through the timeline. The user can scroll the timeline back to view older images. In this case, the timeline flows in the direction opposite to that shown in Figure 2 from (d) to (c) to (b). The user could also return to newer images and following the animation from (b) to (c) to (d). This visualization helps to indicate to the user the direction in which she is navigating. The longer a user holds down a direction on the keypad, the faster the timeline will move in that direction. When the user releases the button the speed diminishes and the timeline comes to rest quickly.

A user can use the touch screen to select and view a larger version of an image. Tapping on the desired thumbnail triggers the animated movement of the image from its current location in the timeline to the location of the viewfinder, gradually increasing the size of the thumbnail until it fills the area designated for the viewfinder. The previous location of the thumbnail in the timeline is now shown as a white frame on a gray background allowing the user to know where this picture resides in the timeline. When an image is dismissed, it shrinks back to the timeline in its appropriate location.

Whenever a user selects a photo to view at a larger size, all other Mobiphos devices are alerted of this focusing. The other devices will then see a colored dot appear in the top-right corner of their screen, where the color is used to indicate which user is performing the focusing action. If another user wants to view the photo of interest, they can tap on the dot in the top-right corner. This will slide in a window which shows the focus of all users in the group. To view the same photo as another user they can tap on that photo. This will both dismiss the window and scale up the chosen photo. The user can also dismiss the window without choosing any photo.

3.1 Implementation

Due to the lack of programmable standalone digital cameras, Mobiphos was implemented on a Motorola E680i Linux-based camera phone (Figure 3). The application was developed in Python. PyGame, a wrapper for SDL, was used to create the user interface elements and the standard Python socket library was used for networking the devices together over WiFi (802.11b). Additionally, we developed Python modules to allow for direct interaction with the camera. The E680i is held in “landscape” mode to give it the



Figure 3: The Motorola E680i running Mobiphos.

feel of a standard camera. Our implementation of Mobiphos shares images with other users by finding other instances of itself attached to the same wireless network. As each image is captured by a user, it is saved locally and sent to all of the other devices in the group. When Mobiphos cannot send a picture to a device, it queues the picture and sends it the next time the unavailable device appears on the network.

To facilitate data collection for our study, we added a logging component to the software. The application recorded its start and end times, any navigation of the thumbnail timeline, scaling of images, the capture of images, and the sending of images and receiving images over the network. All entries were timestamped in milliseconds and were tagged with a unique, anonymous participant identifier.

4. METHOD

We employed a mixed-methods design in our study of Mobiphos. Our goal was to understand how the sharing capabilities of the system might impact a small social group and the ways in which they captured photographs. To do this, we decided to study existing social groups of two to four individuals and how they used our collocated photo sharing technology while on a self-guided walking tour through the city. We collected quantitative and qualitative data both during the walking tour and during post-tour debriefing sessions.

4.1 Procedure

At the beginning of the study, participants completed a survey about their prior use of camera phones, digital cameras, and picture sharing services. In this survey, participants also described the last time they had shared photos from their camera in a face-to-face setting as well as the last time they had viewed photos from another individual's camera in a face-to-face setting. Researchers then demonstrated the Mobiphos system to the participants. All participants demonstrated that they knew how to use all of the system features prior to undertaking the tour. Groups also received a tour brochure featuring a map and descriptions of five historic sites, such as churches, hotels, and theatres, all within approximately one square mile in an urban setting. Once any final questions had been answered, the tour began.

Three researchers accompanied each group. Two researchers took field notes about participants' use of the technology during the walking tour, noting, for example, conversations and observable behavior associated with technology use. Having two researchers

taking field notes for each group was essential, as participants often wandered away from the group briefly to explore different vantage points and group members often divided up to hold multiple conversations while walking from site to site. A third researcher carried a router for WiFi connectivity, ensured that it was generally at the midpoint of group members when they wandered, and was available to address any potential technical issues experienced by participants.

After the walking tour, a researcher downloaded the groups' photos into a custom application implementing a sorting task. The sorting task software asked each participant to do the following: (1) from the set of all photos taken by all group members, identify your favorite photographs, (2) from the set of favorite photographs you selected, identify those that *you* took, and (3) from the set of photographs you took, identify those that you would choose to share with the other group members. Once all participants had completed the sorting tasks, researchers conducted a focus group about the walking tour experience. The focus group interview protocol was semi-structured. Researchers asked a consistent set of open-ended questions to each group, prompting individuals to recall the previous collocated photo sharing experiences they had described in the pre-tour survey and to compare those experiences to their walking tour experience with Mobiphos. Researchers also asked follow-up questions to pursue specific themes that arose in the context of the focus groups. Each focus group was also asked to provide feedback about the usability and usefulness of the system.

4.2 Participants

We recruited eight groups of participants for our study. Each group consisted of two to four individuals who self-identified as an existing social group. All participants were either students or friends and family members of students from our academic institution. Four groups of three or four people participated in the study procedure described above. An additional four groups participated in a pilot version of this study and used an earlier version of the technology. Researchers undertook iterations on both the procedure and the technology in response to feedback from the pilot study participants. However, because of the differences in the procedure and technology the data gathered from the pilot groups is not discussed here.

Participants included nine males and four females with an average age of 26 years. All participants owned technology supporting digital photography and all participants had previously engaged in some form of technology-enabled photo sharing. Eleven participants owned stand-alone digital cameras and ten participants owned camera phones. Twelve participants had used camera phones to take photographs in the past; six participants had used a camera phone to send a photograph to another camera phone user. Those participants who had not sent photographs from one camera phone to another cited the expense and uncertainty about whether a potential recipient had a device that could receive the photographs. All participants had engaged in photo sharing activities via online photo sharing sites such as Flickr or Facebook. All participants had viewed photographs posted online. Eleven participants had posted photos to an online photo sharing site, citing motivations such as wanting to share photos with friends or having received explicit requests from friends to post certain photos.

4.3 Data Analysis

We employed different analytic techniques for the different types of data collected. We applied various common descriptive statistical methods to the quantitative data from the system log files and post-tour sorting task. We analyzed the corpus of photographs

to characterize the types of photos that were taken by participants. We conducted inductive qualitative data analysis across both sets of the walking tour field notes and the notes from the post-tour focus groups. Three researchers collaboratively analyzed the qualitative data, allowing themes of use to emerge from the data.

5. SUMMARY OF RESULTS

WF [from group 1] takes several photos, all in the same general direction, then shrugs and lowers his camera, "I couldn't get it." PF looks down at her camera display and exclaims, "Yeah, you got it!" BM checks his camera display and adds, "That's a keeper."

- Excerpt from Fieldnotes, 27 August 2007

The above exchange among group members was characteristic of the ways in which participants interacted with and around the Mobiphos system. The activity surrounding photographic capture and sharing was often social. Participants took photos. Other participants saw those photos on their own camera displays, often near-synchronously with the moment the photos were captured. Shared photos often grounded group conversation and interaction.

Overall, the 4 groups and 13 participants took a total of 479 photographs during the walking tour for an average of 36.8 images (SD=14.1) per participant. Each group amassed on average a shared archive of 120 photos. Participants clicked to zoom in and view an average of 35.8 (SD=25.3) of those photos. Participants clicked to zoom in and view, on average, 10.6 (SD=8.3) of the photos they had taken and 28.0 (SD=16.7) photos that other group members had taken. This overview of data suggests that participants were actively engaged in sharing and taking part in examining other group member's photographs while on the tour.

The types of photographs taken using the Mobiphos system included the iconic landmark photographs characteristic of tourist photography [7] as well as the social, playful, mundane and serendipitous photography characteristic of camera phone use [3, 13, 17, 19]. In addition, participants crafted new types of photographs that were fostered by the particular affordances of collocated-synchronous photography (Section "Spectrum of Appropriation").

6. DISCUSSION

6.1 Collective Photography

Most participants in our study seemed to develop a sense that the pictures taken were part of a single, shared collection of photographs. This perspective is revealed through several different practices that emerged during our study.

Each group collectively took many photos during their walking tour and many participants actively used the software to review both their own and other group members' photographs. The collective nature of the photographic activity also fostered discussion, delegation, and negotiation about who would take certain photos. For example, when group 1 passed an acquaintance on the street, BM announced to the group that just "one person" should take his photo. The delegation of photo capture suggests that participants viewed the collection of photos as a collective, shared archive.

Participants reported that they did alter their photo taking behavior because of the shared repository. For example, many participants noted the photos that had already been taken by the group before deciding to take additional pictures; their intent was to avoid having too many of the same photo. WF, a member of group 1, reflected on this behavior: "I didn't want to have redundancy.

I was surprised I didn't take a lot of photos. I thought, 'Oh, they already have it.'" Another member of the same group, PF, reflected that the collection of shared pictures made her "[think] more about what other people would want pictures of."

The sense of having one common repository is also reflected in the participants' thoughts about ownership of the photographs. Our pilot study participants told us that they wanted to know who had taken which photo. After our pilot testing, we added the colored borders to the photographs in the timeline to help designate who took which picture (Figure 1). The use of the current system by our subsequent participants indicated that the participants cared about who took photos, not so they could "own" their own photos, but so they could talk about the shared photos. The ability to reference a photograph based on who had just taken it helped the participants develop common ground [8] in their discussions about the photographs. Any deeper notions of ownership seemed to reflect a tie to the whole set of the group's photographs, and not the ones any particular individual captured. Our quantitative data also reflects this finding; 62.4% (142 of 222) of the photographs taken that were marked as an individual's favorites were taken by other members of the group.

While developing the system, we anticipated that we might encounter concerns about the automatic sharing of all photographs. In particular, we were cognizant that some participants might not be comfortable having all of their photographs shared with others. In contrast to our initial concerns, however, our data suggests that the shared nature of the experience made the automatic sharing of photographs an acceptable design decision. None of our participants expressed concern about the loss of control over what specific photographs were shared. A participant from group 1, BM, reflected that the sharing of photographs made sense because the experience was shared: "we're in the same space and doing the same thing."

Although participants no longer decided which photos to share, they did maintain control over sharing in two different ways. As photographers, participants exerted control over whether or not a picture was taken and added to the collective archive. As consumers of shared photos, participants also exerted control over whether or not to view a photo. One participant from group 2, GM, commented that he enjoyed having control over what photos to view, noting that "if you wanted to see other pictures, in this system, you could simply do it. You didn't have to ask permission to see others' photos." This same participant also took advantage of the ability to decide not to see a photo; when a group member took a photo of a deceased bird, he chose not to view it.

6.2 The Situated, Shared Experience

An additional theme present in the data was the importance of shared context and the highly situated nature of system use. BM, from group 1, expressed this theme most succinctly: "The occasion to share a photo is when you take a whopper... the time to share is right after you've taken it and you want everyone to know." While photographs might have more enduring value, for this participant, there is value in the ability to share a great photograph with friends in the context in which he captured it. The situated nature of photographs was also valued by those with whom the photographs were shared. GM from group 2 reflected that the photographs taken reflected others' unique perspectives on the situated, shared experience: "The photos you see are kinda raw. What people wanted to take at that moment."

Participants seemed to become accustomed to taking and sharing photos that were highly situated and contextually-dependent. Some participants took photos based on the assumption that others

would view them in the moment, whether they did or not. In one instance, a participant tried to tease other group members by taking a photograph in which the teasing nature was highly situational. In group 1, the two female participants were walking ahead of the one male participant. As they waited for the light to change at an intersection, the two females looked at the groups' photographs on their cameras and WF observed, "Someone is taking pictures of feet" PF responded, "It's [the male group member]!" and then teased that male group member (BM), "Do you have a foot fetish?" BM responded to the verbal exchange by taking a photograph of their backsides. He took this photo believing that the two female group members would continue to browse their photos and see his pictorial response. However, it was just at that moment that the light changed and the females looked away from their devices to cross the street. Unfortunately, the teasing photographic response was not seen by its intended audience until well after its original situated meaning had been lost, leaving both the photographer and those who had been photographed somewhat uncomfortable when the photo was later discussed.

The language of the participants also reflected the situated shared experience of system use. We observed participants create situated "labels" for specific photographs, another method for creating common ground [8]. One participant, for example, captured a photograph of her other group members and immediately declared it to be her "paparazzi" photo. This label was highly contextual, based on the social interactions among group members, but at the same time was also persistent; she was able to use this label without confusion in conversations with group members as much as an hour after the event.

Another example of the situated language use in our study was the continual affirmations that happened among group members during the walking tours. In every group, we observed short utterances such as "Yeah!" from someone viewing a photo that had just been taken. This utterance had an intended meaning that was highly situation-specific to the photograph that had just been taken and directed toward the group member who had just taken it. More broadly, these continual affirmations were likely used as a means to help co-construct the shared photographic practices of the group. By commenting on both the good and not so good photographs, the members of the group were able to negotiate what photos should be taken.

6.3 Where the Individual Meets the Group

All of our participants had previous photographic experience: as photographers, as subjects in the photographs of others, in sharing photos with others, and in having others share photos with them. These previous experiences meant that our participants entered into our study with preconceived beliefs and expectations surrounding the practices of capturing and sharing photographs in social situations.

The difference between individual and group practices was highlighted by particular exchanges between group members. Where individual practices differed from group practices, participants commented on them and these individual practices became topics for conversation. In group 1, for example, PF strayed from the group and bent over to take a photo (Figure 4). A second member of the group, BM, observed this behavior and stared at his display as if waiting to see what she was taking a picture of. He appeared to wait until the photo arrived on his camera and asked, "What is that?" PF explained that "it is a picture of an ironworks in Northern Michigan [the ironworks logo was embedded in a grate in the ground]. Every time my Mom sees one, she takes a photo." Here, her



Figure 4: Ironworks photo from PF, group 1.

individual capture behavior was different enough to elicit comment and became part of the group conversation and experience.

The shared norms of the group that stood in contrast to some of the individual photographic practices were frequently negotiated by group members. All groups engaged in some dialogue to negotiate shared photographic norms and expectations. This dialogue was most apparent when the individual photographic practices varied the most among group members. In group 2, as noted previously, the group encountered a dead bird on a sidewalk. GM noticed the bird and he pointed it out to the group, warning them not to step on it. As the group passed the bird, GF announced that she wanted to take a photograph of it. When GM asked her not to, GF looked to HM for his reaction. HM encouraged GF to take the photo, which she did. GF commented to a researcher that "I want a feature where I don't have to see the dead bird." In the focus group after the tour, GF noted that her decision to take the photograph was socially negotiated. She reflected that "Had both of you told me not to take the picture of the bird, I wouldn't have taken it. But since HM seemed to think it was a good idea, I decided to go ahead and do it."

6.4 Rhythms of Use

Across all three groups, rhythms of individuals' movement and behavior within a group emerged as did rhythms of group movement and behavior over the course of the tour. We classified these two patterns of movement and behavior as micro- and macro-rhythms.

The most common micro-rhythm observed involved repeated patterns of individuals' behaviors within the group and reflected an oscillating pattern of group cohesion and group dispersion. For example, group 2 approached a historic apartment building as a group, all walking together. As the group approached the left corner of the apartment, one group member stopped to take photographs (Figure 5). The two other group members kept walking; a second group member stopped at the center of the building to take photographs from that angle while the third group member continued walking to the far right side of the building, took photos there and eventually broke off from his group entirely to take photos around the back of the building. His group members waited for him at the corner of the building, glancing down at their displays occasionally, presumably to see what he was taking photos of. The participants had arrived together as a cohesive group, dispersed to take different photographs from different positions,

and reformed the group with participants taking time to see what photographs the others had taken while the group was dispersed. This pattern of group cohesion, individual dispersion followed by group cohesion was witnessed time and again across the groups and was the most common micro-rhythm observed by the researchers.

One notable feature of this micro-rhythm occurred when the group coalesced after being dispersed. As individuals began to abandon their own agendas in favor of participating in the group agenda, their behavior changed. As individuals finished capturing their own pictures and began waiting for the group to convene and move on, participants frequently browsed the photos that others took (this claim was confirmed by visually examining system log data). It was also during this waiting period that serendipitous capture events took place. After participants were finished seeking out specific things to photograph, they began to take pictures of what was near to them, while they waited for other group members. Often, these pictures were of other members of the group who were busy capturing pictures on their own. Photographs of other group members taking photographs was a common theme and we discuss this meta-photography in depth later.

Macro-rhythms occurred at the group-level over the course of the entire technologically mediated experience. Groups, as a whole, engaged with the technology at the beginning of the tour and disengaged toward the end of the tour. The engagement process varied for each group, some engaged immediately upon leaving the research building; other groups engaged when they encountered the first landmark on the tour map.

As groups engaged with the tour, the number of pictures taken increased. The level of engagement remained relatively high until the participants had explored all of the historic locations on the tour. At this point, the disengagement process began and the groups' behavior changed. Though the number of pictures captured did not immediately decrease, the content captured began to change dramatically.

It was usually at this point in the tour that the participants began to play with their photographs. This playful behavior manifested itself in several ways. In one group, participants began to explore novel aspects of the interface and to manipulate the photographs taken to exploit these aspects (see Section "Spectrum of Appropriation"). In other instances, participants began taking posed shots of each other, doing silly things such as jumping in the air or pointing to an absurd sign and making faces. Frequently, these posed shots were suggested by one group member and the content of the final photograph was negotiated by multiple group members. After the number of playful photographic activities diminished, participants moved more quickly to return to the research building. Some participants continued browsing photographs on their phone during this time.

In the focus groups, several participants noted that another time that they would like to use the cameras to browse others' photos was the time immediately following a group event (e.g., "over drinks at the bar" afterward; "on the bus ride home"; or later, "at the coffee shop with friends"). These suggestions imply that perhaps the macro-rhythm we observed could be cyclical with group members engaging in an event, spending time fully engaged, disengaging with the event, changing locations and re-engaging with the residual photographic artifacts from the event.

6.5 Collaboration and Competition

Just as individuals contributed to the micro-rhythms of the group and as individuals contributed their own photographic practices to the shared practices of the group, individuals' interpretations had over the collective agenda had influence. Some individuals

interpreted the collective agenda to be collaborative, some individuals interpreted it as competitive, and others described different interpretations at different times during the tour. Each group was made up of individuals with a variety of these interpretations. Participants who viewed the experience as competitive revealed their interpretation in conversations with other group members about who had taken a better picture of a landmark. This interpretation often resulted in multiple people taking multiple pictures of the exact same thing. This introduced redundancy into the set of photographs collected by the group and was a frequently-discussed point of interest in the focus groups (e.g., HM from group 2 mentioned that "even though we both took the same picture, I chose hers [in the selection task] because it was better than mine").

Collaborative interactions among group members were even more frequent. When reconvening after dispersing to take photographs of a historic church, GM from group 2 commented to himself that "this is like distributed work." He had let other group members take pictures of the stained glass windows while he focused his attention elsewhere. When asked about this comment later in the focus group, he explained: "We had just read [in the tour brochure] about the historic stained glass windows. I was certain that the other members of the group would take pictures of the windows so I let them focus on that while I decided to take a picture of something else."

Other examples of collaborative behavior included instances in which groups negotiated the distribution of photographic work. For example, when the members of group 1 approached a two-sided sign, BM raised his camera to take a photo. WF asked, "Are you getting both of them [sides of the sign]?" and BM responded, "You get one; I'll get the other."

6.6 Gift Giving, Taste, and Identity

Drawing on Mauss' anthropological study of gift-giving [22], other HCI researchers have identified gift-giving practices in mobile computer-mediated communication [28]. Our data reflects what we believe are similarly motivated practices but with a slightly different character due to the tight coupling between photo capture and sharing with Mobiphos. Instead of *sending* text or multimedia messages as gifts to recipients, our respondents spoke of *capturing* photos specifically for other group members. Like most participants, PF from group 1 "thought more about what other people would want pictures of." She took photos, such as those of other group members, which she believed her group members would value. She gifted those photos to the other group members through the collective archive.

Interwoven among participants' reflections about taking photos specifically for other group members were interpretations of others' photographic styles and preferences. HM from group 2 explicitly told us about the kinds of photographs his group members were interested in. He believed that GM, for example, was more interested in "architectural" photographs in contrast to his own interest in pictures that were "weird and outlandish." The awareness and fostering of distinctions among the types of photographs different group members contributed to the collective archive shares some affinity with Bourdieu's sociological study of distinction and his claim that "taste classifies" [5]. In contrast to the economic class distinctions of Bourdieu's research, our participants frequently made distinctions among group members' different levels of artistic and photographic expertise. The awareness and fostering of individual photographic preferences may also reflect practices related to identity management [12] that previous HCI research has shown to be applicable both to digital media [29] and to collections and archives, more broadly [16]. Our data also



Figure 5: Photos captured by group 2 as they split apart at a building to take photos from different perspectives.

suggests that there were tensions between participants wanting, on one hand, to maintain a shared group identity and to contribute photographs that were similar to the photographs others took, and participants wanting, on the other hand, to have a unique identity within the group and to contribute photographs that no one else would think to or be able to contribute.

6.7 Spectrum of Appropriation

Participants utilized the Mobiphos system in a variety of ways, some of which were anticipated while others were not. As expected, the technology supported the synchronous capture and sharing of photographs within a collocated group. In two specific instances, participants appropriated the technology in unanticipated, novel ways. For example, GM from group 3 decided to use the timeline feature of the interface to form parts of a composite photograph that would use the entire screen area to display a single picture. He took sequential, offset pictures of a building, walking a few meters to take each new photo. As the interface updated and the picture he had just taken advanced along the timeline, the offset photos representing adjacent areas of the building’s facade lined up in the interface. In this manner, he used the interface to construct a single picture of the entire side of the building. Notably, this novel appropriation would not have worked if any other group members had taken additional photographs during the same time. Because group members all had displays in which they could observe his photographic behavior, they were able to wait until he was finished to take their photos.

Another more collaborative appropriation involved the same group and their construction of “Matrix-esque” images. Members of group 3 arranged with each other to take the same picture from multiple angles at the same time, creating a three-dimensional visual account of an artifact from multiple perspectives.

7. FUTURE WORK

These seven themes surrounding the collocated-synchronous capture and sharing of images suggest that this domain of technical investigation and empirical investigation is extremely rich. This study reflects an initial foray into examining the emergent practices of this genre of networked digital photography. For future work on the technology of Mobiphos, we would like to port our application to other devices that have better cameras. We would also like to explore using 3G+ mobile phone networks to share the photographs. This technology could eliminate the dependency

on WiFi while also providing interesting opportunities to extend the social experience and real-time sharing beyond the immediate collocated group of users.

We also believe it would be interesting to undertake a more in-depth analysis, specifically exploring photographic memes and the ways in which particular styles or genres of photography move throughout groups and beyond into other groups with overlapping social networks. How does the visibility of others’ photographic styles and preferred genres of photographs influence the photographic activity within and among groups?

Finally, we would be very interested in deploying our application in other realistic settings. It would be very interesting to see how larger groups would utilize Mobiphos and to see how it scales to support more users. Likewise, it would be interesting to deploy the application in more complex social settings and for longer periods of time to explore the impact of the application’s real-time sharing capabilities. For example, a longitudinal deployment in which we send the system overseas with a group of summer study abroad students and monitor their use of the system for a three month period could reveal totally new rhythms and patterns of use as the social dynamics of the group change over time.

8. CONCLUSIONS

As suggested by Becker [4], we have seen with Mobiphos a blending in the practices of capture and sharing resulting from the synchronous, collocated, highly situated nature of the system’s use. The issues surrounding production and consumption with this type of system have become integrated and conflated in a way that is much more compelling than a superficial examination of the component technologies might suggest. Innovations in imaging, networking and mobile technologies have enabled a dramatic increase in computational abilities, and when put into the hands of users, we can enable very rich practices. With Mobiphos, users have been able to blend both the individual and social aspects involved when taking photographs in a small collocated social group to create a novel user experience.

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