Searching Common Experience: A Social Communication Tool Based on Mobile Ad-hoc Networking

Michimune Kohno
Interaction Laboratory
Sony Computer Science Laboratories, Inc.
3–14–13 Takanawa-Muse bldg.
Higashi-Gotanda, Shinagawa-ku
Tokyo 141–0022 Japan
mkohno@csl.sony.co.jp

Jun Rekimoto
Interaction Laboratory
Sony Computer Science Laboratories, Inc.
3–14–13 Takanawa-Muse bldg.
Higashi-Gotanda, Shinagawa-ku
Tokyo 141–0022 Japan
rekimoto@csl.sony.co.jp

ABSTRACT

As small digital cameras become more popular, opportunities to take photos are rapidly increasing. Photo sharing is a great way to maintain and revitalize relationships between families and friends, and is a major motivator for content sharing. While photo sharing has been well studied, little work exists on sharing multiple photo sets contained in spontaneously connected handheld devices.

This paper provides an algorithm to extract photos, based on *common memories* collected in an ad hoc group. It automatically searches for and presents photos that could become the starting point of a conversation. We found that our mechanism has more uses than simply organizing photos in chronological order.

This paper describes our prototype system realized using the above algorithm. We also implemented a *synchronized shutters* mechanism, that provides a new photo sharing experience. Through subjective tests, we found that our method promotes conversation, even though the users did not know each other beforehand.

Categories and Subject Descriptors

H.1 [**Information Systems**]: Models and Principles; H.1.2 [**Models and Principles**]: Human factors—*social networking, ad-hoc computing*

General Terms

Human Factors

Keywords

Social networking, ad hoc computing, photo sharing, colocate communication, common memories, synchronized shutters

MobileHCI'05, September 19–22, 2005, Salzburg, Austria.

1. INTRODUCTION

The rapid development of computer networks and the widespread use of small digital cameras have increased the opportunities for photo sharing. Photo sharing is a popular way to maintain relationships between families and friends [2, 4], and is a major motivation for content sharing. It has been well studied, mainly in the CSCW research area.

Frohlich classified photo-sharing activities into four well-known categories[7]. They are: same place – different place, and same time – different time.

Past research on co-location photo sharing, or, photo sharing at the same time in the same place, described the idea for communication and sharing memories between people, using a single handheld device or a fixed installation, such as a desk. However nowadays, most notebook PCs and personal digital assistants (PDAs) have wireless network interfaces. This led us to develop a whole new co-location photo sharing experience. That is, people carry around their handheld devices and create spontaneous ad hoc networks, in which they can take and share their photos.

Interestingly, even though ad hoc networks have been thoroughly studied, there is relatively little work about content sharing. Speakeasy [6, 5] described network infrastructures as "off the Internet" communication environments. While they also tried to share content, they did not consider it from a social network perspective.

This paper first describes co-location photo sharing in ad hoc computer networks as a way of spontaneous social networking. The *photo sharing* described in this work focuses upon sharing photos the handheld devices have. While distant photo sharing has been thoroughly investigated (e.g. [15, 14]), there is little work on photo sharing in such situations.

Then we describe a system that provides an easy user interface for setting up ad hoc groups. Our system also reminds users their *common memories* by searching for content about shared experiences.

When a device group is created, the properties of all the scattered content in the devices are collected. Such properties include a timestamp, geographical location information (e.g. latitude and longitude), and a set of values that represents a feature quantity. To determine similarities, we used histograms comprised of timestamps taken during a specific time window. This method is more useful than simply checking timestamps within a certain threshold.

In addition, in order to make it possible to actively create common experience we implemented a special data transmission protocol. When an interaction occur in a device within a group, it is transmitted to every other device using a multicast packet. Then, the event occurs on all devices with only short time differences. Using this protocol, we synchronized the camera shutters so that when a user takes a photograph, all the other cameras in the group take a photograph at the same time. These images are automatically gathered and shared within the group's devices. This feature allows us to easily share content that has the same timestamps.

The remainder of this paper is organized as follows. In section 2, we give the background and related work about our research. Section 3 describes the algorithm used to extract content similarity from a device group, and section 4 gives a general system overview and explains how users can set up an ad hoc group and operate our system. Section 5 gives more details about the system implementation, and in section 6, we discuss the implications of our system in terms of social networking. Finally, in section 7 we conclude this paper.

2. BACKGROUND

There is plenty of research about photo sharing, such as [9]. Co-location photo sharing is a very effective cornerstone for face-to-face communications [4]. Whittaker et al. showed that informal communication in close physical proximity plays an important role in future communications between people [17, 8]. Frohlich et al. investigated how storytelling works during co-location photo sharing [7]. They showed that the ratio of storytelling during whole conversation is not significant, but is used as cornerstone on which to build future communication. Our work was greatly influenced by theirs.

... Sharing photos in person is a very common and enjoyable activity. Such co-present sharing is seen as a way of recreating the past and reliving the experience with others who were there at the time.

Additionally, it was found that looking at *printed* photos in person is far more interesting than sitting in front of a display and looking at them.

With this in mind, we would like to discuss the meaning of *sharing*. Their work only discussed to share experiences recalled by *a single set of* photos with co-located people. Thus, the purpose is to share experience among family and friends. In fact, it described that people are likely to use photo sharing as catalysts for conversation more extensively with their extended family and friends, which helped to improve individual relationships over distance and time. In contrast, we aim to introduce photo sharing into ad hoc social communications, regardless of whether the people involved are family, friends or strangers. Frohlich's work did not suggest what the motivation for their findings might be. In addition, they did not consider the influence of user interfaces on photo sharing.

There is also a lot of research on the influence of social communication on ad hoc computing. Edwards et al. described Speakeasy as "recombinant computing" [6, 5]. They constructed a communication infrastructure by proposing a set of resource discovery protocols. Their ultimate goal was off-line communication, the same as ours. Aoki et al. proposed a voice chat system in an ad hoc group [1]. It attenuates the volume as the physical distance between people increases. It also provides dynamic association control when a user tries to enter an established group. This is done by measuring the users's direction using an electrical compass.

Borovoy et al. proposed Meme Tags[3], a social message exchange system that uses the same name tags commonly used in formal meetings. Each short message is called a "meme", and memes are exchanged via infrared signals when participants face each other. Because the exchanges occur in chains, memes are sent to a large number of the participants. This work can be categorized as ad hoc social communications from an off-line perspective. While this is applicable to photo sharing, it is difficult to share with more than three people at one time.

FishPond is a tangible game interface, based on co-locate informal communication[18] that allows us to share spontaneous experiences. While it shows the importance of tangible informal communication, photos are basically lifelong content.

As described above, there is a lot of research about co-location communication. However, little work has studied in terms of searching photos based on **common memories** gathered from ad hoc groups.

3. COMMON MEMORIES IN AN AD HOC GROUP

To begin with, what are photos based on common memories? For our research, we considered the following two types. The first was photos taken when people attend the same event. In other words, photos taken at the same place and at the same time. If a system that could automatically search a subset of photos that satisfy specified conditions from the enormous number of photos, spontaneously collected from handheld devices on an ad hoc networks, we would have more to remind us about the experience, and we could re-live the moment as if we were actually there by talking about it with each other.

Another type was a set of photos taken at the same place, but at different times. Even though such photos are not acquired during common experience, they are still meaningful because photos of a place people have visited have more potential to initiate conversations on the basis of shared interests. This is especially useful when group members are not acquainted with each other. In such cases, the fact that they have a shared experience can be discovered by searching photo collections and can lead to a conversation, and perhaps even a friendship.

To sum up, our goal is to extract subsets of photos that satisfy the above conditions from photo collections.

3.1 Premises

We assumed the following conditions.

- Each photo data has a timestamp that indicates when the image was captured. If the photo file is EXIF file format, and it contains timestamp information in its header, we adopt that value. Otherwise, the file creation time is used.
- Each image file optionally contains geographical location information obtained from a GPS.
- Photo sharing is processed using physically proximal handheld devices carried by the participants.

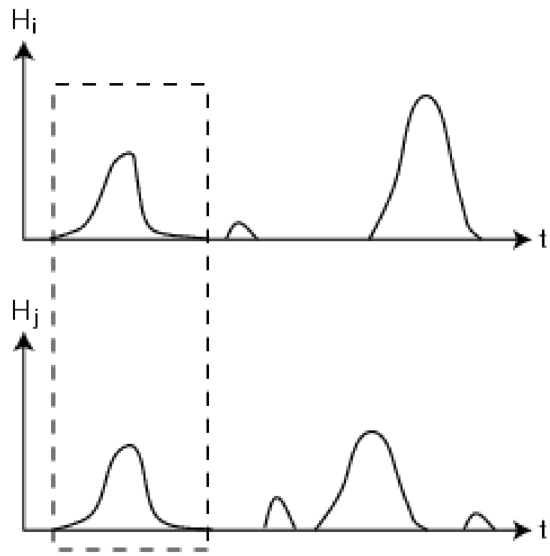

Figure 1: Searching similar regions using timestamp histograms.

- Each handheld device is equipped with a digital camera, WiFi network interface, LCD, and an electrical compass.

Obviously, there are not many handheld devices equipped with electrical compasses. However, we applied this device to enable easy-to-use photo sharing user interfaces. The details will be described in a later section.

3.2 Finding Common Memories

This section describes the algorithm used to extract common memories from the ad hoc group.

3.2.1 Timestamp Histogram Similarity

How can we search for photos taken at the same time, in the same place? Suppose that some people participate in an event and each of them has a digital camera. They often take photos when they see something that they like and want to remember it.

For example, ordinary Kodak moments that occur during a wedding reception include blinding flashes when everyone takes pictures at the same moment. As a result, there are many photos whose timestamps are very similar. Therefore, the timestamps and image characteristics of the photos acquired during the reception are strong correlated. On the other hand, those who did not attend this event does not have any photos whose timestamps are correlated to the reception's photos.

Our algorithm exploits this phenomenon to search correlating photos. It calculates the similarity between timestamp histograms of photos taken during a certain time window (Figure 1, and then compares their similarities using a threshold. In addition, the feature quantities obtained from the images are also used for more precise recognition.

Let $\boldsymbol{X} = \{X_1, X_2, \cdots, X_n\}$ be the set of time stamp arrays, and $\boldsymbol{H} = \{H_1, H_2, \cdots, H_n\}$ be the set of $\boldsymbol{X}$ histograms. Each histogram is an array of the occurrence frequency. That is, $H_n = \left\{h_n^1, h_n^2, \cdots, h_n^W\right\}$, where $W = (t_{\max} - t_{\min})/\Delta t$. $t_{\min}$ and $t_{\max}$ are the earliest and the latest timestamps, respectively, which are determined by scanning $\boldsymbol{X}$.

Let $R_{ij}(k)$ be the similarity function between H_i and H_j during time period $[a, a+N]$, where $0 < a < W - N$ and N is a constant value. Note that a certain time t during the time period is obtained by

$$t = a + k\Delta t \tag{1}$$

$R_{ij}(k)$ can be represented as follows:

$$R_{ij}(k) = \frac{1}{N-k} \sum_{n=a}^{a+N-1-k} H_i(n+k)H_j(n), \qquad (k = 0, \cdots, N-1). \tag{2}$$

Because $R_{ij}(k)$ indicates how similar H_i and H_j are, all of $t, R_{ij}(k)$ where $R_{ij}(k)$ is more than a specific threshold are recorded into an array. t is calculated from Equation 1.

Then a moves forward and $R_{ij}(k)$ is calculated again until a reaches $t_{\max}$. When the iteration finished, the saved t and $R_{ij}(k)$ are sorted in ascending order. If no tuples were saved, a search process using image similarity follows, as described in the next section.

3.2.2 Image Similarity

The main concept of the above algorithm can be applied to searches using the number of similar image features, to extract common memories taken at the same place, but at a different time.

The principle is to search similar photo sets acquired during a specific period of time by two different people. In other words, it searches the time windows in which similar photo images are contained. The image feature quantities used in this algorithm are as follows.

A photo image is split into 3×3 areas, and the ratios of R, G, and B for each area are calculated. We used the results obtained from the vector of the 27th dimension as the image feature quantities. Of course, using any better algorithm will improve the search result. However, it is out of scope of our current work. In this paper we use the simple algorithm.

3.2.3 Execution Timing

When a new ad hoc group is generated, each device tries to collect the timestamps of photos contained in the other devices. After all the exchanges are finished, the search algorithm is activated on each device. The algorithm tries to collect the thumbnails of photo images scattered throughout the device group. Because the protocol is HTTP-based, a thumbnail request is issued as an HTTP GET request. Every device must be able to run an HTTP server to accept such requests. When a server receives a GET request from a device within the ad hoc group, it returns the desired content.

4. MAKING AD-HOC GROUP

Clearly, some type of user interface is needed to make an ad hoc device group. This user interface should be intuitive and easy to operate. This is especially important for novice users.

There is a lot of research on establishing network connections easily [11, 12, 10]. All of it describes the use of special media, such as infra-red signals and buttons, as the out-of-band secure transmission path, and are aimed at providing

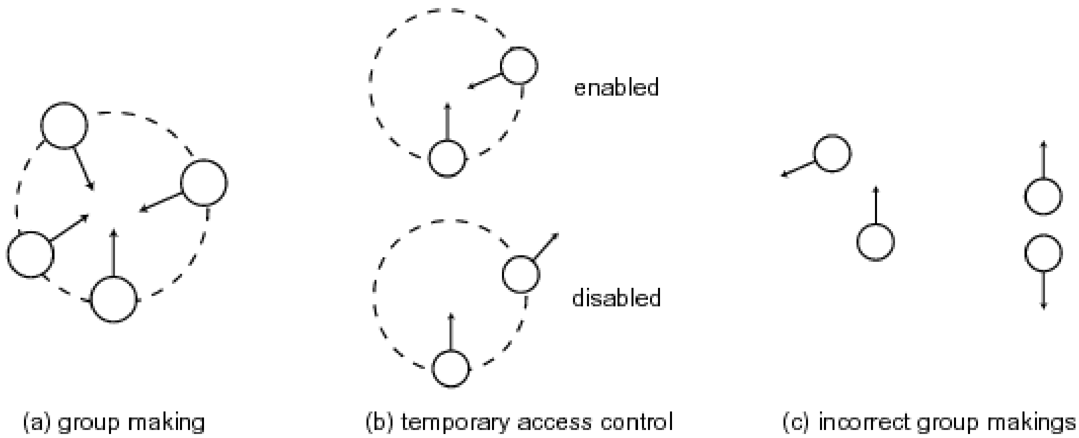

Figure 2: (a) Example of making a group (b) Users temporarily control their perspectives by moving in the opposite direction, (c) Examples of the wrong way to make a group.

user interfaces that can easily connect the two network ends. Thus, it is hard to directly apply them to make a group of more than three devices. Moreover, user context arised *after* connection is not taken into account.

To ease this problem, we used a couple of types of information: the signal strength of WiFi packets, and the device orientation obtained from the electrical compass. These all make it easier to establish ad hoc groups, and reflect the users' context during connection.

4.1 Users' Direction

Generally, in order to grasp the positional relationship of devices, location information is required. A location system is necessary to obtain information from the GPS. However, location information from a GPS receiver is not accurate enough to physically co-locate handheld devices. However, they are usually ineffective indoors, in actual photo sharing events. In terms of indoor positioning systems, there is some past research and commercial solutions available. One system, UbiSense[16] is highly accurate. However, people do not always share photos from places where location systems are installed.

On the other hand, electrical compasses are complete small circuits that do not require an infrastructure. In fact, some commercial camera phones already have electrical compasses that are used for real time navigation to obtain the device orientation. However, it is impossible to grasp the positional relationship of the devices only from their orientation. This is serious dilemma.

To solve this dilemma, we assumed the following situation; when people are making a new group, they stand in a small circle and hold his/her handheld device in front of them (Figure 2 (a)). The orientation of each device is transmitted to other devices as the reference orientation. This remains valid until the group disbands. By subtracting another user's orientation value from yours and checking the results, you can determine whether a user is on your right or left side.

After a group is made, users can change their orientation and control their access control by simply changing their orientation. Figure 2(b) illustrates this feature. When users reverse their orientation, then photo sets from other group members will be temporarily unavailable. When the user faces them again, photos can again be shared. In other words, photos can only be shared while the users are facing each other.

Clearly, this has limitations. For example, if two people are standing as shown in Figure 2(c) and create a group, the resulting orientations will not match the correct positional relationship. Also, when they change their positions after creating a group, the resulting orientations will not match as well. Even though this presents a confusing problem, we chose to ignore it in this paper and instead focused on the advantages described above.

4.2 Group Generation

You can easily create a group by following these steps. First, set the device to group making mode. Second, position your handheld device near the others' in a small circle. When someone pushes a button of Device A, then Device A will transmit a multicast packet, called a GROUP GENERATION packet. Each device that receives the packet measures the signal strength of the multicast packet. If the signal is stronger than the threshold, Device B sends a JOIN REQUEST packet back to Device A. Otherwise the packet is silently discarded. The request packet consists of B's IP address and current orientation. Device A checks the signal strength of B's packet. If it is also stronger than the threshold, A registers B into the internal group management table. Device A waits for reply packets for a short period of time. When a timeout occurs, Device A transmits JOIN packets to all the devices registered in the group management table. Each JOIN packet consists of the IP addresses of all registered devices, as well as A's reference orientation. At this time all devices begin the photo sharing process.

Each device periodically transmits a KEEPALIVE packet containing the current orientation to group members. Every node that receives the packet checks the signal strength and orientation value to update the user interfaces. If the signal strength is under the threshold, or the orientation is reversed for a certain period of time, the entry in the group management table will be disabled. When the orientation returns, the entry will be enabled again.

Figure 3: Photo sharing using our prototype system

5. PROTOTYPE IMPLEMENTATION

We implemented a prototype system running the above algorithm. We used three handheld PCs, Sony VAIO-U (Celeron M 900MHz, RAM 256MB) and USB cameras. Figure 3 shows how the system was applied. Three people held their devices, which were connected using an ad hoc (IBSS) wireless mode.

To obtain the signal strength of wireless packets, we used a MELCO 802.11b CF card as a wireless network interface, instead of the embedded WiFi. We also attached a camera to the back of each handheld PC so that we could use it just like a digital camera. We used Linux and Java J2SE 1.5.0 platforms.

We made a small circuit of the electrical compasses and connected it using a USB. We used Aichi Microelectronics AMI100 to sense the orientation. We also used a small tilt sensor for compensation.

Figure 4 shows our prototype system. In the figure the photo sets of three people are shown. The bottom photo bar shows person A's photos, the bar on the left the shows person B's photos, and the bar on the right side is person C's photos. Person A is in the center, B is on the left and C is on the right. Following the Rodden's work[13], the photos are shown in chronological order. If a photo has strong correlation to any of other user's photo, it appears on a larger scale. In other words, if the picture is big, it is recognized as a common memory. For example, in the center of Figure 4, person A and B's photos are very similar.

The photo shown in the bottom center is person A's photo. You can scroll and change the current photo. The point is that when you change the current photo, everyone else's photo bar also changes to show the one most similar to your updated photo. That is, group members can simultaneously browse each other's photo bars, which is a completely new experience.

Figure 4: A screen snapshot. Three PCs are connected to each other. One is on the left and the other is on the right.

The timestamp histogram is shown in the bottom of the window. It indicates the location of common memories in the photo set. Members can directly jump to photos by pointing to a location on the histogram bar.

5.1 Clock Operation User Interface

We built some simple gesture operations into our system in order to provide intuitive user interfaces. We used a built-in touch screen device.

The timestamp of the current photo is displayed in the center of the window. This works as a clock user interface.

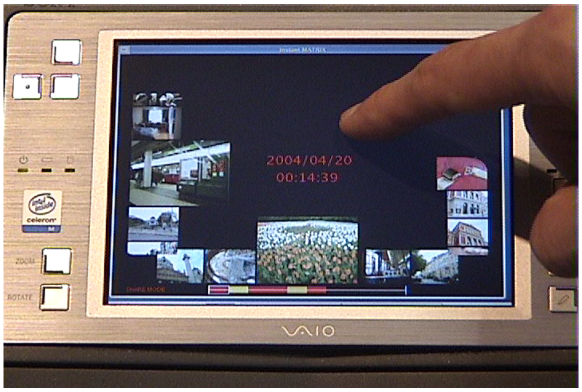

Figure 5: By turning the hands on a clock, users can intuitively browse their current photos.

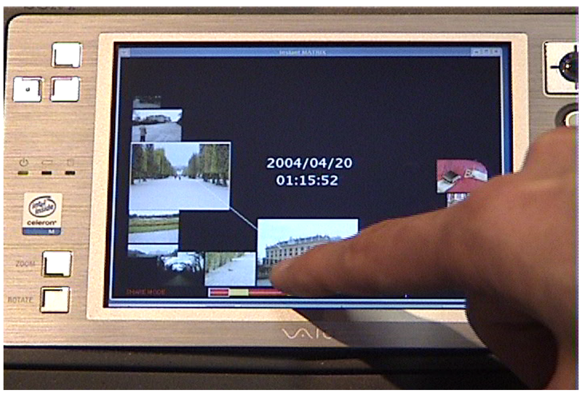

Figure 6: Photos are transferred using a drag and drop operation.

Users can change their current photo by placing their finger on screen and moving it as you would move the hands on a clock (Figure 5). As you turn the clock either clockwise or counterclockwise as desired, all the photo bars are updated to show the best image which is correlated to the current photo.

5.2 Drag and Drop

"Drag and drop" is, of course, supported. If you want someone's photo, you can simply drag it and drop into your photo bar (Figure 6). Conversely, you can give your photo to someone else by dropping it on their photo bar.

Note that when a photo transfer occurs, the histogram also changes. Therefore it is recalculated and updated.

In addition, you can even give another member's photo to someone else. At present, we do not have a clear idea about how this feature can be used and whether it is required. However, we are going to investigate it further.

5.3 Have Fun! Sync'ed Shutters

We implemented the **synchronized shutters** mechanism that allows us to *actively* create common memories. It enables people to synchronously acquire images from the cameras of other members in an ad hoc group.

The basic idea is as follows. The timestamps of photos captured simultaneously are the same. If these photos accumulate, the timestamp histograms during the period also become the same. As a result, their similarities are quite high and they are recognized as common memories.

Figure 7 shows a scene in which people are taking photos using synchronized shutters. In this figure, the three people on the left are taking a picture of the man standing on the right. These handheld users have already constructed an ad hoc network. When someone in the group pushes a shutter (i.e. pushing a tactile button mapped to capture operation), a capture request event is broadcast to all devices. The devices then obtain the image almost immediately.

After all devices have taken a picture, a photo collection process is automatically invoked. Each of the devices executes an HTTP based file transfer system as a background process. When data arrives, it is displayed on screen sequentially (Figure 8).

6. DISCUSSION

While we did not perform any user tests, our subjective tests suggest generally positive reactions to our system. We found that automatic presentation of photos, based on shared situations can help keep the memory of the event alive much longer than simply looking at organized thumbnails.

Browsing multiple photo sets was also well received. The feelings experienced by scrolling multiple photo streams by rotating the hands of a clock was described as feeling like time travel.

We found that reflecting the positional relationships into user interfaces by using wireless signal and user orientation did not work well as we have expected. When group members were in close proximity the connections worked well, but otherwise, unexpected status changes occurred. This was more frequent when people tried to take pictures using synchronized shutters.

The synchronized shutter mechanism was very interesting. In our experiment, we took more than 1,200 photos, some of which were useless because users sometimes shot a picture before the others were ready. However, we were able to share photos from locations where we could not take them. This was a new experience and enjoyable feature.

From a technical viewpoint, the wireless connection sometimes presented problems, the synchronized shutters were not synchronized, and the delays were more than one second. Automatic photo collection was sometimes incomplete, and we have not yet solved this problem. Basically, we believe the major reason is that IBSS mode of the 802.11b card is poorly implemented.

7. CONCLUSION

This paper describes a system for extracting photos based on common experiences in an ad hoc group. It shows that using the similarities of timestamp histograms and image feature quantities can provide good search results. It also describes our prototype implementation and illustrated the new photo sharing experience.

While we found that using positional relationships is useful, the system does not yet meet our requirements. Currently we are considering a kind of indoor positioning system, such as UbiSense.

In this work, we did not consider privacy issues. However, in practice this could be a serious problem. We would like to obtain more feedback from our users about this issue.

Figure 7: Using synchronized shutters.

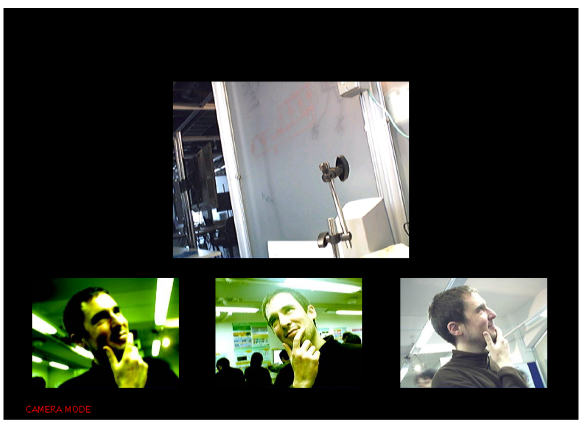

Figure 8: When one person captures a photo, everyone captures one. Their photos are automatically collected and displayed. The bottom three figures are photos taken using synchronized shutters.

8. ACKNOWLEDGMENTS

We would like to thank Dr.Yoshifumi Nishida for his design of touch screen processing software. We also would like to thank Dr.Atsushi Shionozaki for software installation and some other important help. We express our appreciation to all other members of the Interaction Laboratory, Sony CSL, for their support.

9. REFERENCES

[1] P. M. Aoki, M. Romaine, M. H. Szymanski, J. D. Thornton, D. Wilson, and A. Woodruff. The Mad Hatter's Cocktail Party: A Social Mobile Audio Space Supporting Multiple Simultaneous Conversations. In *ACM CHI2003*, pages 425–432, April 2003.

[2] M. Balabanović, L. L. Chu, and G. J. Wolff. Storytelling with Digital Photographs. In *ACM CHI2000*, pages 564–570, April 2000.

[3] R. Borovoy, F. Martin, S. Vemuri, M. Resnick, B. Silverman, and C. Hancock. Meme Tags and Community Mirrors: Moving from Conferences to Collaboration. In *ACM 1998 Conference on Computer Supported Cooperative Work (CSCW98)*, pages 159–168, October 1998.

[4] S. Counts and E. Fellheimer. Supporting Social Presence through Lightweight Photo Sharing On and Off the Desktop. In *ACM CHI2004*, pages 599–606, April 2004.

[5] W. K. Edwards, M. W. Newman, J. Sedivy, T. Smith, and S. Izadi. Challenge: Recombinant Computing and the Speakeasy Approach. In *ACM MOBICOM2002*, pages 279–286, September 2002.

[6] W. K. Edwards, M. W. Newman, J. Z. Sedivy, T. F. Smith, D. Balfanz, D. K. Smetters, H. C. Wong, and S. Izadi. Using Speakeasy for Ad Hoc Peer-to-Peer Collaboration. In *ACM 2002 Conference on Computer Supported Cooperative Work (CSCW02)*, pages 256–265, November 2002.

[7] D. Frohlich, A. Kuchinsky, C. Pering, A. Don, and S. Ariss. Requirements for Photoware. In *ACM 2002 Conference on Computer Supported Cooperative Work (CSCW02)*, pages 166–175, November 2002.

[8] Q. Jones, S. A. Grandhi, S. Whittaker, K. Chivakula, and L. Terveen. Putting Systems into Place: A Qualitative Study of Design Requirements for Location-Aware Community Systems. In *ACM 2004 Conference on Computer Supported Cooperative Work (CSCW04)*, pages 202–211, November 2004.

[9] H. Kang and B. Shneiderman. Visualization Method for Personal Photo Collections: Browsing and

Searching in the PhotoFinder. In *Proceedings on IEEE International Conference on Multimedia and Expo (ICME2000)*, pages 1539–1542, July 2000.

[10] M. Kohno, Y. Ayatsuka, and J. Rekimoto. TACT: Mobile Terminal for Session Manipulation. In *Proceedings of 1st International Conference on Mobile Computing and Ubiquitous Networking*, pages 26–31, January 2004.

[11] M. Kohno and J. Rekimoto. New Generation of IP-Phone Enabled Mobile Devices. In *Proceedings of 4th International Symposium Mobile HCI 2002*, pages 319–323, September 2002.

[12] J. Rekimoto, Y. Ayatsuka, M. Kohno, and H. Oba. ProximalInteractions: A Direct Manipulation Technique for Wireless Networking. In *Proceedings of INTERACT2003*, September 2003.

[13] K. Rodden and K. R. Wood. How Do People Manage Their Digital Photographs? In *ACM CHI2003*, pages 409–416, April 2003.

[14] R. Rodenstein and J. S. Donath. Talking in Circles: Designing A Spatially-Grounded Audioconferencing Environment. In *ACM CHI2000*, pages 81–87, April 2000.

[15] M. A. Smith, S. D. Farnham, and S. M. Drucker. The Social Life of Small Graphical Chat Spaces. In *ACM SIGCHI2000*, pages 462–469, April 2000.

[16] UbiSense. http://www.ubisense.net/.

[17] S. Whittaker, D. Frohlich, and O. D. Jones. Informal Workplace Communication: What Is It Like and How Might We Support It? In *ACM CHI1994*, pages 131–137, April 1994.

[18] J. Yoon, J. Oishi, J. Nawyn, K. Kobayashi, and N. Gupta. FishPong: Encouraging Human-to-Huamn Interaction in Informal Social Environments. In *ACM 2004 Conference on Computer Supported Cooperative Work (CSCW04)*, pages 374–377, November 2004.