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The Ubiquitous Camera: An In-Depth Study of Camera Phone Use

An in-depth study produced a six-part taxonomy that describes how people use camera phone images for social and personal purposes and affective and functional purposes. Reviewing the taxonomy reveals implications for future products and services.

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The worldwide boom in mobile phone penetration has forever changed the global technology landscape, and mobile phone operators are looking to further capitalize on this huge market. They have high hopes that, following text messaging's success (especially in Europe and Asia), "picture messaging" using camera phones will establish photos as a new genre in mobile communication.

Indeed, some grounds for optimism exist. Recent statistics in Japan report that camera phone sales now exceed 50 percent of the mobile phone market.[1] Furthermore, major operators such as J-Phone have reported that over 70 percent of mobile phone customers also subscribe to MMS (multimedia messaging service).[1]

However, although sales figures are good for the units themselves, it's not clear to what extent people are using camera phones to send picture messages. Recent media reports have described early results as disappointing.[2] Many possible explanations include obstacles such as cost, reliability, and interface complexity. Alternatively, a camera phone's value might not lie in sending images but in using the captured images for other activities.

Unfortunately, little in-depth data exists regarding what users actually do with their camera phones (see the "Previous Research into Camera Phone Use" sidebar). Our study's goal was thus to understand how people use these devices to help steer a course for facilities that people will truly value. We had two main objectives. The first was to explore the range and diversity of use to help broaden our outlook on current and future camera phone use. The second was to elucidate the characteristics and context of use for different activities to learn how we might better support such activities.

Method

From May through July 2004, we interviewed camera phone users and collected and examined the images they had captured or received on their phones.

Subjects

We recruited 34 subjects: nine youths and 10 adults in the UK (mainly from the Bristol and Cambridge areas) and four youths and 11 adults in the US (mainly from the San Francisco Bay area). We classified youths as between the ages of 16 and 21 and adults as over 21. We aimed for an equal number of males and females in each group, but the UK sample had more males (74 percent).

Subjects used a variety of camera phone types and service providers and had, on average, 8.6 months of camera phone experience. Most of the phones had VGA resolution cameras (640 × 480 pixels) without a zoom or flash. Nine subjects had phones that could capture video. All but three of

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Previous Research into Camera Phone Use

Camera phone research is very much in its infancy. Related research includes literature on using still photos and other forms of mobile communication such as text messaging. Such research areas are themselves relatively new although some seminal work exists.[1,2] What's clear is that each of these different technological contexts has its own affordances for interaction. However, we have yet to establish the extent of their relevance to camera phone use.

With regard to camera phones themselves, most of the existing research focuses on the sending of images rather than on the range of ways in which people use their camera phones. One of the earliest studies in this area was the Maypole project.[3] Carried out prior to the release of commercial camera phones, Maypole provided small groups of users with prototype devices and looked at the sending behaviors of two socially connected groups of people. The study showed how participants sent images to support group cohesion, express affection, support conversation, and tell stories. A study carried out by the Finnish telecommunications company Radiolinja found similar results.[4]

More recent studies have reviewed the types and context of communication carried out via MMS, including using camera phones for work-related communication[5] and for certain aspects of domestic communication (such as problem-solving and time management).[6]

Only a few examples of research on uses beyond capturing and sending images with camera phones exist. Most notably, Daisuke Okabe[7] recently published an ethnographic study of mobile email and image use. Although this work sheds light on emerging social practices, it's not focused on design implications for new technologies.

Our study examines the entire range of activities that constitute camera phone use with an eye toward designing future technologies. Furthermore, unlike previous research on groups of individuals known to one another as friends or other socially connected groups, we recruited a wider cross-section of individuals, most of whom were experienced camera phone users.

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the subjects had access to MMS sending facilities, and all but five had General Packet Radio Service enabling email access. Some also had infrared or Bluetooth for transmitting images directly to other phones, and everyone had access to a PC at work, school, or home.

Procedure

The study consisted of two interviews, conducted two to five weeks apart. During each interview, we asked the subjects to show us five images (photos or videos) from their camera phones. To keep the selection random, we asked them to show us whatever image appeared every few clicks on the phone's image browser. However, we asked them to show us only images that weren't private, and we passed over images that were similar to ones already selected and taken at the same time.

For each selected image, we asked:

- What does the image show, where do you keep it, and did you capture or receive it?
- If captured, what was your intention when taking the picture, and what was the context within which you took it?
- If received, who sent the image, when and how did the person send it, did he or she annotate it, and can you conjecture as to its purpose?
- Can you detail any uses of the image (originally intended or not), including context of use, whether you shared it (and how), and whether you annotated it?

During the first interview, we also collected background demographic information, information about the subject's experience with imaging technologies, and statistics about the images on the phone. During the final interview, we logged basic data on images sent, received, and archived since the first interview, and we probed users about any difficulties they had experienced. We also tried to gauge the technology's perceived value and asked subjects what other uses they'd like the technology to support in the future.

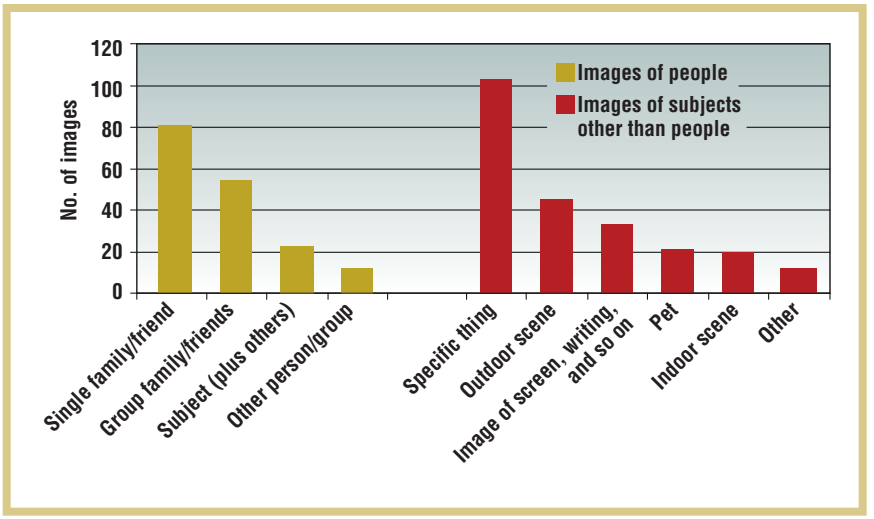

Figure 1. Camera phone images categorized by the subject depicted.

The main part of our analysis, which we present here, concentrated on the randomly chosen images. (A separate report discusses the remaining data.[3]) Our analysis involved coding the data collected for each image—such as the intention behind taking a picture. We each independently produced a coding scheme and then worked together to establish sensible coding categories. Our goal was to build a framework for understanding the data rather than to prove any a priori hypotheses.

General camera phone use statistics

When we conducted the first interview, most of the images on the subjects' phones were ones they had captured (average 44) rather than received (average 2). Also, the nine phones with video capabilities contained three times as many photos as videos. By the time of the second interview, subjects had acquired on average an additional 24 photos. Five of the subjects with video capability had also acquired a few videos.

We can look at these statistics in more detail by combining data from the first and second interviews to consider the activity's entire life cycle:

- *Capturing:* The average rate of photo capture between interviews was approximately eight photos per week or 34 per month. For those with video capability, the video capture rate was much less than for photos: approximately three videos per month.
- *Receiving:* The average rate of photo receipt was approximately two per month. (Negligible sending or receiving of videos occurred between the two interviews.)
- *Sharing:* Most image sharing took place face to face, almost always on the phone's screen but sometimes by direct phone-to-phone transfer over infrared or Bluetooth, or by MMS. To send images to remote users, 22 subjects used MMS and 12 used phone-based email. The average rate of sending photos directly from the camera phone during the study was approximately six per month (after discounting one outlier subject, whose rate of image sending far exceeded any other's). Additionally, 12 subjects reported sometimes sending their photos via their PC because they couldn't use the sending services or the recipient didn't have a capable phone.
- *Printing:* Only 12 subjects reported that they printed photos captured or received on the phone, and most said they did so only a few times a year.
- *Archiving:* The average rate of archiving between the two interviews was approximately 15 photos per month. (Negligible video archiving occurred.)

In total, across all subjects and interviews, we collected data on 303 photos and 17 videos. The images depicted a range of subjects, categorized by content type in Figure 1 (although sometimes two content types occurred in a single image). The most frequent content type was people (51 percent), followed by pictures containing a specific thing (32 percent)—for example, a rare book, a car, flowers, a shopping item, food, or a building.

Although the subjects of these images reveal something about the types of images people like to capture, it's the stories behind the pictures—why they were taken and how they were used—that provide real insights into camera phones' value.

A taxonomy of reasons for capture

We focus here on the intentions behind the captured images (rather than received images, which comprised less than eight percent of the images on the subjects' phones). Intentions varied along two dimensions. The first delineates whether the subjects captured the images for *affective* (for example, sentimental) versus *functional* reasons. The second delineates *social* versus *individual* intentions. For social intentions, subjects reported capturing images to enhance or support sharing with other people. We can further break down this category into sharing with people present at the time of image capture versus sharing with those not present. Individual intentions were those in which subjects captured images for personal use.

This breakdown results in six intention categories (see Table 1). Of the 295 captured images, 22 percent had more than one intention reported.

Affective categories

The subjects captured affective images for some sentimental or emotional reason, such as joking or showing affection for someone else or evoking an emotional reaction in oneself.

TABLE 1

A taxonomy of reasons for image capture, with numbers and proportions of images by category.

	Social		Individual	
	Description	**No. of images**	**Description**	**No. of images**
Affective	*Mutual experience.* Images intended to enrich a shared experience (either in the moment or later).	103 (35%)	*Personal reflection.* Images intended for personal reflection or reminiscing.	120 (41%)
	Absent friends or family. Images intended for communication with absent friends or family (either in the moment or later).	63 (21%)		
Functional	*Mutual task.* Images intended to share with people present at capture, in support of a task (either in the moment or later).	11 (4%)	*Personal task.* Images intended to support some future task not involving sharing.	29 (10%)
	Remote Task. Images intended to support a task by sharing with remote family, friends, or colleagues (either in the moment or later).	23 (8%)		

Mutual experience. The most common social reason for capturing an image was to enrich a mutual experience by sharing an image with those who were present at the time of capture. Most of these images focused on people and were taken at social gatherings, often in public venues such as a pub or restaurant or on a trip or outing with others.

Users shared a mutual experience either "in the moment" to enhance the experience or later as a memento. The majority of images fell into the first category (59 percent), where taking a picture and sharing it immediately with others enhanced a social occasion, marked an event, or showed the value placed on an experience. Sometimes the picture-taking was almost a social end in itself. One younger subject remarked, "We were swapping phones and taking pictures of one another using one another's phones." However, most images were about a specific occasion. Motives ranged from joking and gentle provocation to a more straightforward celebration of being together. For example, the image in Figure 2a shows one young subject's friend engaged in making a parachute out of a plastic bag. The subject jokingly took the photo as a way of "embarrassing her childish friend."

The second main type of intention in this category—sharing images as mementos—comprised 48 percent of the instances in this category. For example, Figure 2b shows a memento of a bride-to-be on her "hen night," a traditional party thrown for the bride (or "hen") by her female social circle. Another subject took a picture of his wife and mother together on a trip and later emailed the image to them. Many other images of family and friends were captured to be shared with those people at a later time.

The reality of how subjects used the images in this overall category wasn't straightforward. Most were shared but usually in the moment and on the phone itself. Subjects reported only one instance of sharing an image by sending it to the phone of somebody else also present at the time of the event.

Furthermore, sending after the fact, even if intended, had often not occurred by the time we interviewed subjects. Many said they simply hadn't "gotten around to it yet." The implication here was that the time and effort required to send the images was difficult or inappropriate to achieve in the moment, and people seemingly later lost the impulse to share.

Finally, subjects expressed a strong desire to keep these images long term—they wanted to keep approximately a third of the images indefinitely on their phone and about half longer term on a PC or (occasionally) on the Web. Poor image quality often arose as a problem in this respect, undermining the desire to archive or print the images as mementos.

Absent friends or family. Images in this category were intended to share or communicate an experience with absent people. This could happen either in the moment to share an event as it unfolded or after the fact. Images in this category were predominantly of specific things (60 percent) that had some shared meaning for the absent person (followed by people, which appeared in 36 percent of the images).

Figure 2c shows an example of extending an experience to absent friends: the subject was at a music festival, which she shared in the moment by sending an MMS image of her muddy boots. The next two examples are more about the relationship between the people involved than about the sharing of a particular experience. One subject communicated the arrival of a box (Figure 2d) in an MMS message to tease the recipient, because the box contained audio equipment he wanted. Figure 2e shows a riddle that one subject sent to her husband concerning a gift for him that had just arrived.

Many of the images in this category not only used an object's shared mean-

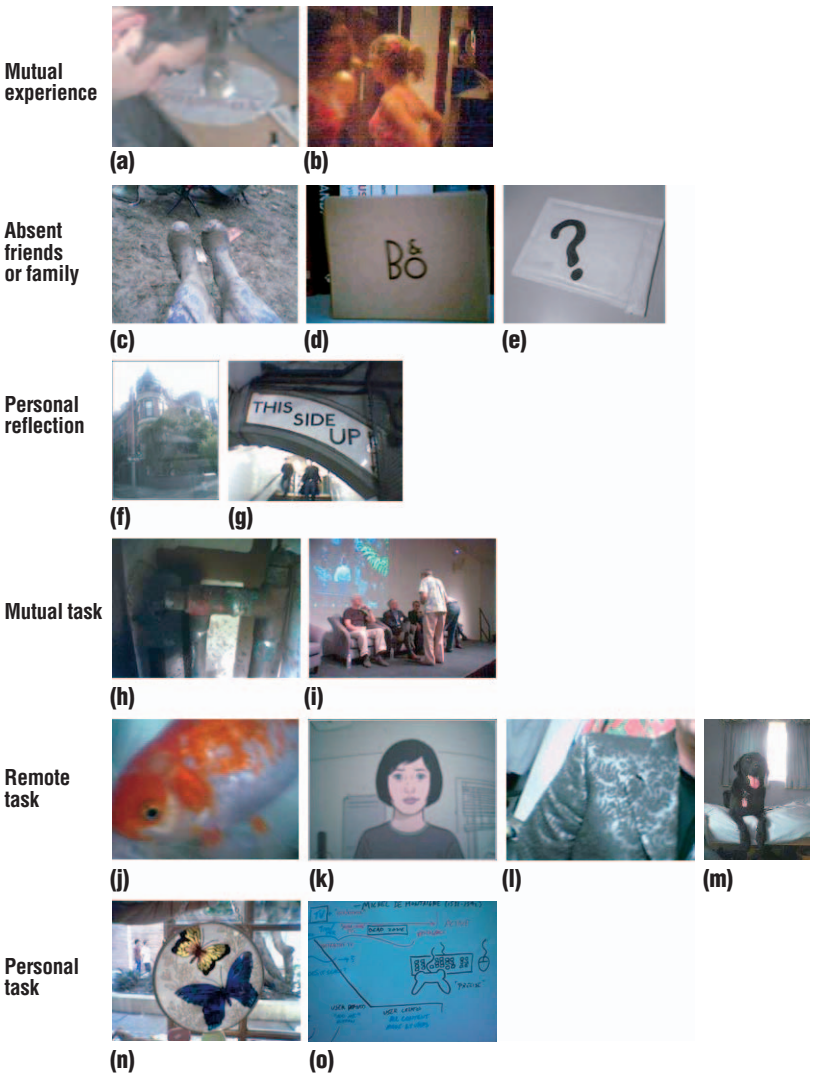

Figure 2. Images by intention category. *Mutual experience:* images taken for (a) teasing and (b) a memento of a "hen night" (bachelorette party). *Absent friends or family:* (c) sharing muddy conditions at Glastonbury festival, (d) teasing about a desired object, and (e) presenting a riddle. *Personal reflection:* images (f) showing personal aspiration and (g) signifying a personal achievement in having entered a subway station despite earlier panic attacks. *Mutual task:* images showing (h) a plumbing problem to be solved jointly and (i) a meeting to be recorded in minutes on the Web. *Remote task:* (j) a reminder to feed the goldfish, (k) a picture of a haircut to take to the hairdresser; (l) possible material for a wedding; (m) evidence that the dog is being looked after. *Personal task:* (n) a gift idea and (o) writing on a whiteboard. (Photos reproduced exactly as captured by subjects.)

ing—demonstrating a shared history between friends or family—but also drew value from the contemporaneous connection made possible through the camera phone. Drawing someone into an experience in real time despite being separated by distance represented a compelling way to stay close. One subject described it as a "telepresence," saying it made his absent girlfriend feel as if she were "here to see it." Twenty-seven percent of the images in this category were shared in the moment. Furthermore, most of these images were also tightly woven into an ongoing conversational context using a range of technologies, and, again, real-time interactions were an integral component. For example, one subject took a picture of his new car in immediate response to receiving a friend's picture of his new motorcycle; the pair then had a discussion by phone. There were also several cases of users sending picture messages while communicating by email and instant messaging on a PC.

In addition to sharing in the moment, many images in this category were later either shared on the phone itself (38 percent) or sent (16 percent). Most were sent directly from the phone but a few were emailed from a PC, posted on a Web page, or printed and mailed in a letter. This post-hoc sharing typically involved story telling with absent friends and family.

Similar to the mutual experience category, about a quarter of the images were never shared with absent friends and family, despite an initial intention to do so. In some cases, the subject had lost the impulse to share the images, but another problem was poor image quality. Although only a sixth of these images were intended to be kept long term on the phone, subjects expressed a desire to keep about half of their captured images in this category long term on a PC.

Personal reflection. This category, the largest of the six, encompasses images captured for individual reflection or reminiscing.

Subjects' comments indicated that portability and the ability to capture and carry images was important. As one person said, "It's nice to capture a little moment to carry with you. It's a memento." Such images were thus similar to digital flipbooks of favorite images or photos kept in a wallet. Many were

carried to keep some treasured person or object close, such as family, friends, pets, or gifts of emotional value. Other images had a more personal or private meaning. One woman carried a photo of the house she aspired to own (Figure 2f). One man captured a sign at a subway station, which signified that he had overcome his panic attacks because he previously would have experienced such an attack in the location where he took the picture (Figure 2g).

Although such images were intended for personal reflection, two thirds of them were also shared, usually by showing them on the phone to others after the fact and opportunistically (56 percent). Additionally, 24 percent were sent from the phone or via a PC.

Similar to the mutual experience category, subjects reported that they intended to keep approximately a third of the images on the phone indefinitely and save about half on a PC. About 10 cases involved using images for phone wallpaper or for associating with friends or family in their contact lists.

Functional categories

Functional images were more practical—subjects used them to support a particular task.

Mutual task. This category comprised just 11 images, captured to complete a task with people present at the time of capture. Half of the images were involved in only a relatively trivial form of "task," where subjects were demonstrating or experimenting with their camera phone's functionality.

However, other images were used to complete more substantial tasks. Some served as a shared record required to discuss a task the participants needed to complete, while others captured an object's current state before work began. For example, a couple took a picture of pipes related to a plumbing task so they could bring the picture to the store with them (Figure 2h). In another case, a man took a picture as a record of a museum event and later integrated the picture into the event's minutes, sharing it with others who were present (Figure 2i). Although too few examples exist to draw general conclusions about this class of images, they demonstrate ways in which records of shared experiences can be a useful part of various tasks.

Often the person used the image to tell or remind a remote person about something that needed to be done or to discuss it with them.

Remote task. In this category, the subjects captured images as part of a task shared with people absent at the time of capture. This was also a relatively small category, but it contained interesting examples of images supporting tasks.

Most of the images (77 percent) were of a specific thing connected with the task. Often the person used the image to tell or remind a remote person about something that needed to be done or to discuss it with them. For example, the goldfish in Figure 2j had a text annotation saying "feed me," because the subject wanted to remind his daughter to feed the fish while he was away. Figure 2k depicts a sample haircut, which the subject took to her hairdresser. The man who found the jacket in Figure 2l sent the image straightaway to a husband-to-be, recommending that he visit the shop for his wedding attire. Another subcategory of these images was to prove to an absent person that a commitment had been fulfilled. Figure 2m shows the healthy state of a dog that the subject was looking after while its owners were away. Another subject assured his mother he had landed safely by sending a picture of the disembarked plane.

These examples demonstrate the importance of timeliness. Sometimes images were more effective when shared in the moment (such as the photo of the disembarked plane), or at least within some short time window (such as the happy dog). Others were used to capture information to use later, to share either face to face (as with the haircut) or remotely (as with the wedding attire). The fact that about half of these images were sent rather than later shown to others reflects the importance of time.

Personal task. This is the largest of the functional categories and covers a range of reasons why people took images to support some practical, individual task. About two-thirds of these images showed specific things involved in a task.

Many of the images in this category were used to record information for later reference. For example, one woman captured gift ideas while shopping (Figure 2n). A man took an image of a whiteboard (Figure 2o) to remind himself of comments in a meeting. Detail was sometimes important, such as a car registration number one person captured after an accident. Finally, images as a reference source were sometimes a collection of images: one man took pictures of objects in scrapyards to use when thinking about his future sculptures.

Other functional uses included personal reminders (for example, one youth took a picture of his friend to remind himself that he needed to send him a message).

As with the previous categories, most of the images in this category were kept short term on the phone, mainly until they had served their purpose.

Age, geography, and gender

It wasn't a primary goal to examine demographic differences, but we did test for statistical differences for many of our key measures across age (youth versus adult), geography (US versus UK), and gender. Overall, only two differences of statistical significance occurred. First, youths had a greater proportion of images than adults in the mutual experience category ($p = 0.027$). Second, males captured significantly more images than females in the personal task category ($p = 0.014$).

Discussion

Our study found that camera phones support more diverse activities than previous data might suggest and in a wide variety of contexts.

Nature of sharing

There was little evidence of a strong "capture and send" culture among the study's subject (as noted earlier, less than eight percent of the images on the subjects' phones had been sent to them by other people). However, two thirds of the images examined were captured to share, mainly for affective reasons. The majority of image sharing (one third of all images) took place face to face on the phone itself. This kind of sharing was usually fluid—casual and spontaneous, sometimes going beyond the original capturing intention. Subjects mentioned that the main thing they liked about their camera phones was that they're always on hand.

Only about one fifth of the images were shared by sending directly from phone to phone (largely via MMS), owing to barriers such as expense, complexity, or poor image quality. Another barrier was the lack of a critical mass of people with whom to exchange images. The subjects in our study said they knew on average about eight people who had camera phones. However, they reported that they sent images to only 2.5 people on average and received images from only 1.9 people on average.

Despite barriers to sending an image, when users performed such activities, they provided compelling examples of a new form of communication.

Because of their ability to capture and view images anywhere, the subjects often used their camera phones as personal flipbooks of images.

Communicating with images

The combination of camera and direct sending capabilities lets us use images to bring remote people into an experience or to accomplish tasks with them. This is distinct from related messaging activities in several ways. Unlike text messaging, many images sent to absent friends and family were visual evidence of an event. Many such messages were sent with little or no need for further explanation; they made sense because of shared context and understanding, and depended on and symbolized the closeness of a relationship. Such cryptic images (to the outside observer) included playful images, visual riddles, and shared jokes. Unlike images emailed later, they could be captured and shared in the moment, adding an extra dimension to remote sharing by showing when something was happening as well as what was happening.

A new form of communication was also demonstrated by the spontaneous capture of visual information to help achieve a task, such as showing the fabric for a jacket. When information is fundamentally visual in nature, neither text nor voice will suffice. We can send such information in other ways, but the spontaneity of capture lets users take advantage of opportunities to share more flexibly. In addition, sending information to a phone rather than to an email account viewed on a PC takes advantage of mobile connectivity. The father reminding his daughter to feed the fish sent the information to a device he knew she'd have with her, rather than relying on her visits to the PC.

The ubiquitous camera

Because of their ability to capture and view images anywhere, the subjects often used their camera phones as personal flipbooks of images. This also facilitated easy sharing and personal reflection. Indeed, subjects stated a wish to keep 27 percent of their images with them on the phone long term, with the highest proportions in the affective categories. This augmented what we already know about mobile phones in general—that many people feel a strong emotional attachment to them.[4]

Capturing and viewing anywhere also supported more task-related functions, such as documenting an event or creating personal reminders.

Finally, people capture images with their camera phones in places where they often have conventional cameras with them, such as at home, weddings, and planned trips. However, camera phones were used almost as often in places where people typically don't have cameras—at work or school, in social venues such as pubs and restaurants, and when "out and about." Moreover, there was a subgenre of images depicting unconventional subjects, which were taken spontaneously for reasons such as amusement, experimentation, or curiosity.

Implications

Our research suggests a need for significant changes. The overriding implication is that designers need to recognize the diverse range of activities that cam-

era phones support—functional and affective as well as individual and social activities. In other words, their use is much more complex and rich than any simple model of camera phone use would assume. Designers need to understand these activities to support them and the need to move between them.

Capturing and sending, in particular, have the promise of a new and compelling genre of communication, which is currently fraught with problems. Obvious issues we must resolve include reducing technical complexity, lowering costs, and improving image quality (which will happen as a matter of course). We describe other activities in need of improved support in the following sections.

Showing and giving to present people

A key camera phone value is the ability to spontaneously show images, which suggests that finding and browsing images should be as simple as possible. Most users organize their images only chronologically, so finding an image is relatively time consuming. Screen quality and size are also important, although the trade-off in cost and portability is problematic; connecting with in-situ displays is an interesting alternative approach. The iPod Photo is designed to support rapid browsing and searching through numerous images by letting people view them on a TV over a cable (see www.apple.com/ipodphoto). Pervasive computing research has much to offer here in terms of approaches to interacting wirelessly with environmental displays, including the privacy aspects of doing so when the displays are public.[5]

The subjects also often wanted to give photos to those who were present at an event—the impulse to share seemed greatest at the time of capture. The implication is not only that beaming images to single recipients be as simple as possible but that users might also want to broadcast an image to a number of people in the same space, for example at a party or work meeting.

Connecting with absent people

The examples of interweaving images into larger conversational contexts suggests a potential market for applications that let people continue talking or messaging while viewing images, all on the camera phone. The subjects in our studies had to use multiple devices to accomplish this activity.

Creating mementos and records

Even the best images capture a situation only partially, and other aspects might escape later recall or remain hidden to people who were absent. The subjects responded positively to the idea of a camera phone that could automatically capture more contextual information and link it to the image. This might include ambient sounds or identifying where the image was captured and with whom. Or it could even provide incidental parts of the context such as the weather.

Deleting and archiving

Users tended to store many images on their phones that they said they'd delete if given the time, and whose presence likely made the phone less useful as a flipbook. This, along with the desire to keep about half of their images long term on a PC (particularly in the affective categories), points to the need for quicker and easier tools to help people sift through and delete or archive camera phone images in potentially large numbers.

The camera phone is neither an incremental step forward from the mobile phone nor a poor relation of the digital camera. Rather, it's a device that's sometimes used

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like a digital camera but differs in the range of activities it supports. Additionally, we're seeing the emergence of new activities made possible—for example, by the combination of image capture and the ability to send. Our study and others point to the seeds of new possibilities for what this technology might lead to in the future. There are plenty of clues in what users do now that point to how the camera phone will evolve and what new products and services it will inspire. In particular, our ongoing research is investigating camera phone use in the short-range interactions our findings suggested. We're extending the phones' Bluetooth capabilities, both for gathering context at the time of capture and for giving images to those who are present at the time of capture. Future work will explore other directions suggested by the taxonomy and driven by users. P

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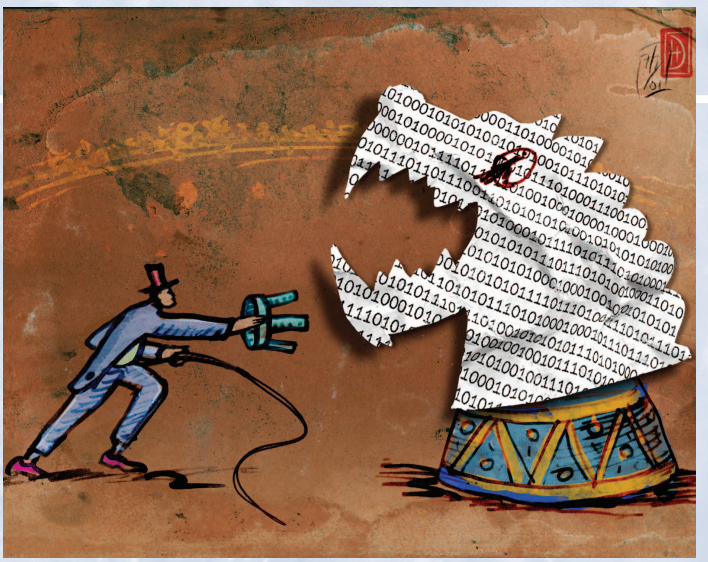

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