Exploring Video Streaming in Public Settings: Shared Geocaching Over Distance Using Mobile Video Chat

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ABSTRACT

Our research explores the use of mobile video chat in public spaces by people participating in *parallel experiences*, where both a local and remote person are doing the same activity together at the same time. We prototyped a wearable video chat experience and had pairs of friends and family members participate in 'shared geocaching' over distance. Our results show that video streaming works best for navigation tasks but is more challenging to use for fine-grained searching tasks. Video streaming also creates a very intimate experience with a remote partner, but this can lead to distraction from the 'real world' and even safety concerns. Overall, privacy concerns with streaming from a public space were not typically an issue; however, people tended to rely on assumptions of what were acceptable. The implications are that designers should consider appropriate feedback, user disembodiment, and asymmetry when designing for parallel experiences.

ACM Classification Keywords

H.5.3 [Information interfaces and presentation]: Group and Organization Interfaces - Computer Supported Cooperative Work

Author Keywords

Shared experiences; video communication; Geocaching

INTRODUCTION

With the proliferation of smartphones and mobile video streaming technologies (e.g., Google Glass), we will soon see an increasing amount of usage of mobile video streaming and mobile video chat from public settings. Yet this is a largely unchartered territory where we do not yet know how people will react to and use such technologies.

Our overarching research goal was to understand how mobile video communication systems could support the sharing of everyday outdoor activities between people who were geographically separated and how people would react to such experiences. We were particularly interested in *parallel experiences*: situations where *both* the local and remote family member or friend were doing the same activity in parallel together, rather than one person passively watching the activity from home. This reflects many situations in life where co-located people go out and do an activity, in parallel, together (e.g., walking, running, playing sports, site-seeing). In these situations, people may not be actively doing the exact same thing together, but they are in essence participating in the same general activity at the same time and in the same location (e.g., similar to parallel play amongst children [34]).

To explore this scenario, we used commercial software and hardware along with a wearable component to create a technology probe [17] that provides two-way video exchange via a smartphone and head-mounted mobile camera. We then conducted a study of the GPS-based treasure hunt game of geocaching where we augmented the activity to make it a parallel experience over distance. We selected geocaching as our focal activity for a number of reasons. First, geocaching includes walking or hiking, which are activities with relatively low physical thresholds where people often converse during the activity. Thus, it is a social activity. Second, geocaching includes navigation and looking for specific items. This requires individual efforts and can also include tightly coupled collaboration. Thus, geocaching contains acts that would be found in other outdoor activities like sightseeing or those involving wayfinding. Third, geocaching can be done in a variety of areas. In urban settings, video is being used in a public area with the risk of privacy concerns. This generalizes to future settings where one may be able to easily record or broadcast public scenes through wearable devices.

In our study, two people geocached in different locations where each hunted for his/her own geocaches but could see the other person's view and converse via an audio link. Thus, people could help each other out as needed, or simply 'be together' while doing the activity. The goal of our study was to understand how the audio and video links supported the activity, the technical or social challenges that existed, and the broader implications of using video streaming in public settings. Our results show that video streaming supported navigation tasks in 'shared geocaching' but it was challenging to use the video feed for fine-grained

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searching activities. We also found our technology probe created a 'micro' shared experience between two people where they were somewhat detached from the rest of the environment around them. Most participants saw this as a positive experience; however, it did create safety concerns. Video streaming in public areas was generally seen as being acceptable, yet this was often based on assumptions of what was permitted in an area. Given these results, designers should consider appropriate feedback mechanisms, remote user disembodiment, and asymmetric participation.

RELATED WORK

Video Chat with Family and Friends

Video chat is a technology that has rapidly proliferated in usage in the home for connecting family and friends over distance and many find it extremely valuable for maintaining relationships and feeling close to one another [1,13,22]. Studies have uncovered varied ways family members use existing video chat systems including sharing conversations as well as more detailed activities and shared experiences [4,13]. For example, grandparents and grandchildren share play times together [13], couples connect their homes to virtually "live together" [22], teenagers do homework together, [5] and children share playtime together [34]. Most closely related to our study, O'Hara et al. [26] conducted a study of mobile video telephony that showed that people used mobile video chat in public places (such as while commuting on public transit) to talk with friends or family. In these situations, privacy challenges emerged when bystanders could potentially see the video display or when they were being captured on video. Mobile devices were also found to be awkward to hold for long video calls.

Video Chat Prototypes

We also see new uses of video chat with research prototypes that present 'always-on' portals [15], shared desktop or table spaces for interaction [33], and video embedded tangible objects like storybooks [27]. More specific to our focus, there are also video chat prototypes for sharing *mobile* experiences. For example, Peek-A-Boo [21] supported a video link between a smartphone and an in-home picture frame with the goal of sharing outdoor activities (e.g., child soccer games) with a grandparent at home. Experiences2Go [12] also provided a live-video feed between a mobile device and an in-home display. A study showed that adults like to converse during shared activities. While both Peek-A-Boo and Experiences2Go offer experiences similar to our design goals, in both cases, only one person is mobile and only one person is performing the outdoor activity. Our work explores how *both* parties participate in the experience, in parallel, together.

There are also systems that focus on video records or the production of video from mobile settings. For example, Caleido provided multiple users with a means to collaboratively collect and share video of events [9]. The Mobile Vision Mixer allows film directors to view and combine multiple mobile video streams [10].

Commercial video chat systems such as Google+ Hangouts and Skype are available on mobile devices and can be used to share the types of outdoor activities that we are investigating. Yet we have not seen published studies of how people utilize these technologies in an outdoor context. The closest known activity is the online documented use of Google+ Hangouts for "Virtual Photo Walks" [31] where a person shares video of an experience with people who are unable to leave their home (e.g., on bed-rest). Again, our research focuses on parallel experiences.

Designing for Shared Physical Activities

Researchers have also explored how technology can encourage shared physical activities with others. Consolvo et al. [8] conducted a study of a shared step counting system and found that people valued social support and encouragement from friends. Mueller et al. [20] designed a shared soccer game over video for distance-separated friends. People enjoyed the social atmosphere of playing with a remote person. Stanley et al. [29] designed a GPS-based game where parents created walking routes for their children to follow at a later point; thus, the focus was on asynchronous and not synchronous shared experiences.

O'Brien and Mueller [24] explored social jogging and found that a key problem was finding a jogging partner with the same pace and same start location. They also learned that most people liked to converse while jogging rather than compete with a running partner. People jog with others so they are motivated to run faster, have more fun, and actually go on a jog. Following this study, they designed the Jogging Over a Distance prototype [18,19] that allows two joggers who are geographically separated to jog together. The technology transmits spatial audio to provide a sense of the remote jogging partner's location (same pace, ahead, behind). We build on this research by exploring video's role in parallel experiences, in addition to audio.

Geocaching

Geocaching is a GPS-based treasure hunt where players search for hidden containers that include a logbook to sign one's initials. Forestry studies have highlighted the motivations people have for geocaching [7] and the need for preserving the environment while still allowing people to geocache [6]. Kelley [16] describes how geocaching has moved from forests and parks to everyday urban centers. This creates a paradigm shift for the activity and means it can now easily interweave its way into one's everyday activities. O'Hara's [25] study elaborates on the motivations that people have for geocaching and include giving purpose to walks, improving profile statistics, challenging oneself, and participating and competing with others. Geocaching is also described as a shared social activity where groups of people find and hide geocaches for others [25]. Neustaedter et al. [23] elaborate on this to

illustrate the role of community in geocaching where players create and maintain the game long term.

TECHNOLOGY PROBE

To explore 'shared geocaching' over distance, we created a technology probe shown in Figure 1 that consisted of existing commercial software and hardware. It included a wearable mobile video camera that captured the wearer's field of vision by being attached to an article of clothing such as a hat or a pair of glasses. We used a Looxie 2 camera and an ordinary pair of sunglasses (glasses for evening usage) to prototype the experience. Using a Bluetooth connection and a specially designed smartphone application (by Looxie), the camera transmitted live streaming video to a local smartphone. By leveraging the smartphone's mobile Internet connection, the application broadcasted the video to a remote user's smartphone at 640 x 480 resolution and 24 fps, in the best case. At times, this resolution was algorithmically reduced if network bandwidth became constrained. The camera also captured and transmitted audio to the remote person, so the users could talk to one another throughout the experience. Both parties could send and receive video simultaneously to establish a symmetrical exchange where each could view the other's field of vision.

We modified a wearable runner's armband to hold a smartphone that showed the remote user's video (Figure 1, right). This freed up the users' hands to hold a GPS device (for geocaching) if they wanted to. It also allowed them to look periodically at the remote user's video by looking at his or her arm. This contrasts a head-mounted display (e.g., smartphone attached to a helmet, or augmented-reality glasses), as we wanted to make video selectively available to users. Thus, they could choose when to look at the remote user's video feed. This also meant that the video feed did not obscure a person's normal vision.

Even though it was crude looking, the technology probe sufficed for exploring the experience that we were interested in without investing in large development efforts. This is a critical goal for technology probes [17].

STUDY METHODOLOGY

We conducted a study to explore how our technology probe would be used for 'shared geocaching' over distance. The goal of our study was to understand how the audio and video links supported the activity and what technical or social challenges existed, such as privacy concerns.

Participants and Recruitment

We recruited sixteen people in total for our study—eight pairs of friends or family members—via advertisements on online geocaching forums and within our university community. 10 of 16 participants were between 20 and 30 years old, two were between 40 and 50 years, and four were between 50 and 60; thus, our participants generally represented a young demographic. Occupations included pharmacy technician, special education teacher, journalist,

Figure 1: The 'shared geocaching' technology probe.

videographer, retail salesperson, and students. Eleven participants frequently participated in outdoor activities and ten said that they often went on hikes or walks with friends. All but one participant was familiar with the concept of geocaching, though ten had never found any geocaches. Three people had found between one and four geocaches, one had found more than ten, one had found over 500, and another had found over 1,000 geocaches. Thus, overall, our participants were mostly novice or beginner geocachers with the addition of two highly experienced geocachers.

Given this, our study focuses predominantly on the reaction and experiences of participants to the technology probe and the idea of participating in a parallel experience with video streaming. Thus, we do not report on the broader implications of 'shared geocaching' in terms of the culture and community associated with geocaching and how 'acceptable' community members may find the activity. There are a great number of questions that existing geocachers could have about how to conduct 'shared geocaching' according to the implicit rules of the game. For example, if a person finds a remote geocache with someone, are they 'allowed' to record the find even though they did not actually physically find the cache in person? Our study does not address these types of questions or explore the broader cultural questions about 'shared geocaching' as this would require a different study than the one we conducted. However, we feel this would make for very interesting future work in the area.

Method

Our study method consisted of several stages:

1. Initial Survey – We first conducted written surveys with each participant to gather demographics and obtain background information on how they normally participated in outdoor activities like walking, hiking, or geocaching, if at all, and how this included, or did not, family members or friends. The survey took ~15 minutes to complete.

2. Shared Geocaching – Participants then walked around an area adjacent to our university campus and were told that they should separate and collectively try to find two

geocaches each within an hour time period. The area contained five geocaches that we told participants about within a one kilometer (0.6 mile) radius. The area contained a large shopping mall, parking lot, and an urban park with sidewalks and trees. This meant participants were usually separated by a distance of 100-300 meters, though buildings, trees, and other structures visually separated these areas to create the feeling of a more distant connection. Geocaches ranged in size from 'micro' (a film canister) to 'regular' (a small Tupperware container). They also varied in difficulty. For example, an easy geocache was hidden in a stump underneath some tree bark. A difficult geocache blended in to the environment by being hidden behind a false electrical cover on a parking lot post.

Participants used our technology probe and were told they could use any additional devices or applications that they normally geocached with. We also provided participants with paper printouts of maps showing the location of each geocache along with the information found on each cache's web page. We did this so that all participants would have access to the same basic cache information regardless of whether they brought additional devices or applications.

In this study stage, we were interested in seeing when and how audio and video were used and, if any, what challenges or interesting social situations participants experienced. We imagined that participants would mutually help each other as they hunted for their own geocaches. We also anticipated they would engage in casual conversation about other activities, their surroundings, etc. Alternatively, we could have tried to create nearly identical geocaches in two locations so people could have the exact same shared experience. However, we felt this was largely impractical and not likely to occur more broadly in geocaching. We also purposely restricted the study to geocaches within a walking distance as opposed to ones requiring participants to drive with a vehicle. This would have created a very different type of shared experience and we encourage future studies to investigate this area.

3. Final Interview – After completing the geocaching activity, participants were separately interviewed about their overall thoughts on the experience. We asked them to give us a step-by-step account of the activity, and we also asked them questions about how they made use of the audio and video links and how they interacted with their partner. Thus, we received feedback and descriptions of the activity and the overall experience by all participants individually where responses were not biased by what a partner might have said. At times, participants even commented on the activities of their partner and perceived annoyances.

Data Collection & Analysis

All interviews were audio-recorded and handwritten notes were kept. We analyzed our interview transcriptions and notes using thematic analysis to understand the main and recurring themes in our data. We purposely did not go with the participants to observe them while they participated in the activity because we wanted them to feel as though the only person they were doing the activity with was the remote partner. Going with them to observe could have easily confounded this sense of 'togetherness.' This meant, however, that our data analysis relied on retrospective verbal accounts. We also did not record the video or audio that was streamed through the probe for the same reasons.

Next we present our results based on the themes that emerged in our analysis. First, we outline general reactions to the idea of 'shared geocaching' and how the probe was used. Second, we explain the environmental factors and pragmatics that affected the general usage of the technology. Third, we describe the idea of a 'micro' shared experience within a broader public context. This relates to the role of audio and video, distractions, and exclusions. Fourth, we outline findings on safety. And, fifth, we outline the privacy and social challenges participants faced as a result of the activity and technology.

GEOCACHING OVER DISTANCE

Overall, nearly all participants enjoyed participating in 'shared geocaching' with their partner over distance. Participants expressed the same sentiments that are typical with geocaching: they enjoyed doing a physical activity with someone else, they liked being outdoors, they enjoyed the challenge of searching for geocaches, and they liked the novelty of the technology.

"It was more fun. It was more of a social experience rather than being by yourself. In terms of, even when you geocache with other people, you're finding the same one. Here you have more options, because if you don't find one, you can help someone else find theirs." (P7)

In general, experienced geocachers described the experience as being 'not as good as' geocaching with someone in person but a reasonable proxy if one's partner lived far away.

"It was a different experience…I kept wishing I was there to help him instead of just seeing him and trying to talk him through it. I usually geocache with someone else. And the two of us together, talking through it, looking together, is to me a better idea." (P3)

Some participants struggled with finding geocaches and only found one or two, while others found four of the five geocaches in our study set. Searching success was often based on one's prior experience with geocaching.

As one would expect, not everyone liked the experience. One participant without any geocaching experience felt 'shared geocaching' was not very appealing. Some became frustrated when they could not find particular caches, but this also a common problem with geocaching in general.

Participants told us that they talked nearly continuously over the audio feed, which was said to be the most valuable part of the experience. Conversations focused on discussions of geocaching, the 'new' technology being used, what participants saw around them, as well as casual talk typical amongst friends. Video was used to show the environment around the participants in general. For

example, participants commented on how they showed each other funny things they saw, homeless people they passed by, attractive bystanders, etc. Video was also used to show aspects of the environment that were more specific to geocaching (e.g., landmarks, likely hiding locations, etc).

Navigation vs. Searching

Geocaching typically involves two activities: 1) orienting oneself geographically and navigating to a specific area; and, 2) performing a fine-grained search within a specific location for a geocache container (e.g., a Tupperware container, magnetic keyholder, a film or pill canister). Participants described the technology probe as working especially well for navigating to a geocache's general area. This was because the resolution of the video lent itself most naturally to seeing scenery and a location's general environment, rather than specific attributes. For example, one couple described how they shared a GPS device to find the geocaches. In this instance, the partner with the GPS device directed the other partner by looking at both her GPS device and his video feed to see where he was located.

"[My partner] was able to find her way and I was able to help her by looking at the phone. So I was able to see where she was that way. I could recognize markers outside. So when she was moving her head, looking around, I could see what she was looking at, and I could see a sign for [the store] and I knew exactly where she was and I told her to go right." (P6)

On the other hand, it was often difficult to help remote users with fine-grained container searching once they reached a geocache's general area because the resolution of the streamed video was not high enough to show specific environmental details that might reveal where a geocache container was hidden. Fine-grained searching also required viewing the area at certain angles and distances, which was often difficult for participants to frame with the head-mounted camera.

"I couldn't help [him] find his [geocache] because I had no sense of what he was looking at. He thought he found it...but I think it was a power box the city put there. I looked at his screen to see. I had no sense of orientation. The camera was crooked. The shot was too tight." (P2)

"This way there was a disconnect because you can't be physically right there moving things and helping. And that was frustrating. And what I could see was limited. He was looking down a lot. So I couldn't locate him space." (P3)

In some instances, participants helped with fine-grained searching by pointing out general areas that their partners could look in, but, again, they were unable to help with more detailed searching. Similarly, participants also talked about showing each other the geocache containers that they found so that the less experienced geocachers would know what style of containers to look for.

"The video actually did help where [my wife] helped me with orientation with where the caches might be." (P4)

"[My partner] corrected me and told me I should be in the buggy area. So he's telling me...I looked again, there was a hint of 'black', and I didn't see anything black. He said, 'look up', and I looked up, and there it was." (P8)

"We were talking and seeing where each other were. I was able to see where he was and what he was looking at. He was looking at a log. I tried to get him to look in it. And when I found mine, I showed him so he knew what he was looking for." (P12)

All partner sets tended to use a leader-follower paradigm when geocaching: one person, often the more experienced geocacher, would help out the less experienced person. This caused geocaching conversations and video viewing to focus most often on the less experienced geocacher.

'MICRO' SHARED EXPERIENCES

All participants expressed a strong sense of a 'shared experience' with their partners. What was most interesting about this was that the description of the shared experience was very intimately tied with each participant's partner, despite the experience and activity occurring within the broader context of the public setting that included bystanders. We refer to this as a 'micro' shared experience in the sense that the experience was a microcosm within the larger set of activities and events occurring in the setting where participants engaged in 'shared geocaching'. This is because participants had a very strong sense that they were participating in an activity with only one other person, as opposed to the larger backdrop of people coming and going around them. In this context, participants talked about the audio as creating a very personal link to their remote partner. That is, the audio link provided the strongest sense of connection to one's partner. Video was seen as an additional benefit on top of the audio and added to the sense of a close, intimate experience by providing remote viewers with the view as seen by their partners (a view one typically does not get).

Distraction

Participants were often so engaged in the experience with their partner that they became distracted from the other happenings around them because they were so engaged with talking to and seeing what their partner was doing. This was despite the selective availability of the video (e.g., choosing when to look at one's arm to see the video).

"He's like the voice inside my head. Because with the earphones on you kinda shut out the other noises around you. It's interesting because I'm hearing what he's hearing. It's kinda weird that the stuff I'm hearing might not relate to what I'm seeing. You need to get used to that. Eventually I took out one ear so I could actually hear what's going on around me." (P1)

"Um...I'd say I might have focused too much on trying to see what he was doing rather than doing what I was doing. I may have ignored some of my surroundings." (P2)

Because participants became so immersed in the connection they shared with their partner, at times the activity of 'shared geocaching' became unsafe and participants had to explicitly remember to pay attention to their settings in order to stay out of harm's way.

"I could hear her...so I was paying more attention to her than I was to my own task…I was paying so much attention to the screen that I forgot I was in area with moving cars. So I had to pay a little attention to ...you know, I was in a parking lot with moving vehicles." (P6)

"At first we found that we were watching the screens way too much. When we were walking and one of us came up to a street it would be like, okay, we have to stop watching the screen and focus on crossing the street now." (P11)

Participants often found it difficult to completely focus on both settings—the connection with their partner and their own surroundings—at the same. Both required a large degree of effort in order to follow what was happening.

In addition to this, two participants told us that sometimes they did not like to be always sharing the experience with their partners. For example, one participant preferred to spend some 'individual time' to find her geocache and did not want her partner to bother her:

"He kept busy looking at mine though. He kept saying 'you're walking the wrong way'. I vaguely know where it is so I kept walking and he kept looking at my screen. I found it distracting and told him to mind his own business." (P5)

Another person related the experience to 'living life through a camera lens' where a person is overly focused on a camera and not seeing the world through her own eyes:

"When you're on vacation, and you take a video of something scenic. I do it, and I hate it. Why not just look at it? The video link could take away from certain experiences. Especially with nature and outdoor beauty." (P8)

Appearance and Visibility

Participants also commented on the effects of wearing a 'new' type of technology in a public setting. They felt that the wearable camera made it easy to notice them or get extra attention in a public setting as did the crudeness of the prototype. Many participants described getting looks from other people in the general public resulting from the prototype as well as the ongoing conversations that they were having with their partners. This tended to not bother most people because they felt the looks were associated with being a part of something 'new,' which they were experiencing with their partner, not alone.

"I got a few strange looks from people because I'm walking and talking but you see that more these days anyway. I feel the camera might have looked weird to some people but I didn't notice it." (P3)

Concerns were also explicitly tempered because participants were participating in the activity with someone else who could relate to their feelings about the experience and even see the remote person's situation as it occurred.

"…she was walking through the mall and she said people were looking at her, and I was able to look at the screen and see that people were staring at her." (P7)

As one might expect, not everyone was comfortable with the additional public attention because of the technology probe. A small number of participants expressed concerns about feeling self-conscious because of it. Here the shared experience of participating with someone else was not enough to overcome apprehension.

"Except when I was in the mall...I felt a bit self conscious...I felt like everyone was looking at me. I think people thought it was more weird at first because people could hear me talking to somebody, and then they would look up and see the glasses and be like 'Oh, she's doing something strange.' Especially when it got dark, because the red light stood out a little bit." (P12)

Exclusion

Participants commented that sometimes the experience moved away from being intimate with their partner and this explicitly occurred when the partner began interacting with a member of the general public. For some participants, this 'ruined' the experience because they no longer felt the close connection with their partner. For example, one husband described how he felt completely 'left out' and even spiteful when his wife started talking with a person in the street and asking for directions:

"Then I could overhear [my wife] talking to people in the street asking for directions. And I said well wait a minute, I should be helping you because we're supposed to be collaborating. [I felt disconnected] because now [my wife's] talking to other people. And I know what it's like when you're on the phone and you're talking to people next to you and you've got a voice in your ear…" (P6)

The challenge with the above scenario is that the husband had no way to interact with other people at the remote location. Instead, his interactions were solely with his partner. Moreover, other people at the remote location did not even know that he was a part of the activity because he had no live presence or embodiment next to his partner.

SAFETY

Some participants completed the study during the evening when it was darker and explained that they felt safer because of the video feed. Thus, the video streaming made participants more comfortable to carry on the activity at times during the day when they may not have normally been out alone.

"I liked being able to see where he was what he was doing because I didn't like walking in that parking lot by myself...so knowing someone else could see what I was seeing and what was going on was a nice feeling." (P12)

We also found that safety *issues* can also arise because of the technology. Thus, it does not always mitigate problems; sometimes it creates them. In one instance, a participant ended up in a verbal altercation with a homeless man. The participant was talking to his partner via the headset, and the man passing by thought he was talking to him. The homeless man began shouting at the participant. Luckily he calmed down when he realized that the participant was actually talking to a remote person. Again, in this situation, the participant was thankful that a remote person could see what was occurring on the video feed.

In another instance, the technology probe created a potentially risky situation, as perceived by the participant who felt others might think he was engaging in criminal activity because of the visible wearable technology. This went beyond normal concerns that geocachers often express about being noticed by others (non-cachers).

"People started looking at me a little bit funny. Shoppers, in the parking lot. I assumed they thought I was maybe scoping out cars, like a possible break-in or something. This may be a high-crime area, I'm not sure. I was mindful of that." (P6)

PRIVACY

After their experience, we asked participants if they had any privacy concerns or if they felt that bystanders in the public would have any concerns with them using the technology. We also asked them about any privacy sensitive situations.

Streaming Video in a Public Setting

Participants tended to not think about the privacy of others in the general public without us prompting them. When asked specifically about it, most felt that it was okay to use the technology probe and provided a variety of reasons.

First, participants talked about the difference between streaming video and recording video. Most participants felt that the privacy of others was not being compromised because the video was not being recorded. Streaming video was seen as ephemeral whereas video recording was considered much more permanent and privacy intrusive.

"If you're holding up a camera, it looks like you're actively filming someone. If you have a tiny little camera strapped to your head, and you've synced two devices so you can talk...it doesn't feel like you're actively filming people. It just feels like a private communication between two people. If someone walked by with a head-mounted camera...if they're talking to someone else, I'm not worried about them publishing it because it looks like they're just showing it to someone else in real time." (P11)

Participants did not comment on the lack of feedback within the prototype that, if it existed, would provide bystanders with an understanding that the device was only streaming video and not recording it. There was a common assumption that others would simply know that the device was only streaming and not recording even without such feedback from the device.

Second, participants talked about video streaming being used in a public place and cameras being 'everywhere' already. For example, when asked if she worried about the privacy of others, one participant said:

"No. They're in public…if you're in public you're putting yourself in a spot to be recorded. You're subject to your picture getting taken." (P2)

Some participants described laws that were said to permit photo and video capture in public places without the explicit consent of those being captured. Because of such policies, these participants felt that the technology probe was no different than existing videography and photography activities. Similarly, one participant was a professional photographer/videographer who often filmed live events like weddings and skateboarding competitions. He said he did not have any privacy concerns for other people because he was already very comfortable filming strangers in public because of his profession.

The study also revealed that the notion of what is public vs. private is often obscured. At one point, the shopping mall's security team alerted us that 'filming' was not allowed on mall property (in this case, a plaza outside of stores). Thus, despite it appearing to be a public location, the mall was actually considered to be private property with its own rules for video capture.

Three participants told us they did not feel comfortable streaming video of bystanders while they participated in the study. One person talked about being 'eyed' by security and feeling like she should conceal what she was doing and move along before they hassled her.

"People notice it. People see that I'm recording because of the red light. It kind of worries me getting from place to place. People could see this. So I'm a bit more cautious when I'm pointing it at them. It's like...I'm just gonna go on my way. I'm worried for them because it's not my intention to record them all." (P1)

In one case, privacy became an actual issue between two partners during the study. After initially leaving to find their first geocaches, one participant stopped at the mall bathroom to use the facilities before heading outside. This activity was accidentally broadcast to his partner.

Self-Censorship

While we had told participants that video was only being streamed to their partner, at times participants were not sure if this was actually the case. This was partially a result of the software we used: the Looxcie software application shows a series of public video broadcasts on its home screen, which participants saw when starting the application in the study. These could falsely cause users to think that all streams are set to be publicly available online; in contrast, we had set up each device to only stream between the two participants' devices. Despite this, people still expressed concerns and would sometimes self-censor what they said.

"I just kinda wondered, so you're streaming, now who can see the stream? That was what I was wondering. I think about, okay, so I have to be careful what I say to [my partner]. Just in general. I wasn't overly concerned because it was a study." (P8)

"I think I thought about what I said a bit more in case someone else could hear it. Maybe made less snarky comments to [my partner]." (P12)

This reveals that people still feel video may somehow be broadcasting their call more broadly despite the settings they choose.

ENVIRONMENTAL AND PRAGMATIC FACTORS

We also found a variety of environmental and pragmatic factors that affected the ways in which participants engaged in the activity and experienced the technology. These relate mostly to usability. First, the technology probe was affected

by weather conditions such as rain and sun. Participants who participated in the rain talked about how the glasses would get wet, which would obscure their vision. Similarly, they talked about how the armband holding the smartphone would get wet and make it difficult to see the video display. Those who participated on sunny days complained about glare from the sun on the smartphone case as well as issues of shade when near buildings or trees.

Second, participants sometimes saw the technology probe as being bulky and awkward. The activity of geocaching involves feeling around and touching various surfaces in order to find the hidden geocache container. This was sometimes difficult especially if a person tried to use the hand that contained the armband.

Third, some participants faced pragmatic challenges from wearing the probe's glasses. For example, one participant wore a turban and struggled to get the glasses and camera on his head in a comfortable manner.

Lastly, at times participants experienced video or audio lag. This ranged from a couple of seconds to upwards of fifteen seconds. When it occurred, audio lag tended to be more detrimental to the experience than video lag. In cases when audio began to lag, conversations became completely disrupted. Yet when video lagged, participants could easily wait to see the video 'catch up'.

DISCUSSION AND CONCLUSIONS

Our study has described the experiences of participants in using video streaming as part of 'shared geocaching' over distance. Here we focus on discussing the broader and more complex challenges that should be carefully considered when supporting parallel experiences through video streaming in public settings.

Navigation vs. Fine-Grained Searching

First, we see that 'shared geocaching' and our technology probe worked reasonably well for shared navigation to areas containing geocaches, where the remote participant could see the area and help the other person navigate. This suggests that activities beyond geocaching that contain general wayfinding, navigation, and discussion about locations would similarly benefit from a setup like we had. This might include activities like walking, hiking, or tourist sightseeing.

Yet when it came to more fine-grained tasks, the video stream was not as useful. This related to resolution issues, but we also feel it relates to one's viewpoint and who is in control of that viewpoint. For example, participants commented on the challenges of not knowing where their partner was looking or not understanding the camera's orientation. When it comes to video chat technologies, people are very used to seeing a view of others that shows their face and background. However, in contrast, they are much less used to seeing a first person view, which can be confusing without broader experience and exposure to such views. This type of remote view is also most likely continually moving while one is mobile and walking. This means that the control of what is seen is in the hands of the remote person and not the viewer.

Overall, this suggests that activities that require more fine-grained control and specific views of an area may not immediately benefit from setups like our technology probe, unless the viewer has more options of controlling what is seen. This might include situations like sightseeing if a person wants to show a remote friend a specific aspect of a building. It could also occur in 'shared shopping' situations if a person is trying to show various items in a store over video chat. Potential solutions include having cameras capture a larger, panoramic view of an area, where remote viewers can choose what portion of the view they get to see with the ability to zoom in to such regions. This may also alleviate potential issues with 'bouncing' video images because of movement.

'Micro' Shared Experiences

Our technology probe was also especially beneficial for creating an intimate shared experience with one's remote partner. We described this as a 'micro' shared experience because of its placement within the broader context of happenings around the participants' activities (e.g., bystanders and their activities). Yet this too created some challenges.

First, participants could easily become distracted from the 'real world' because of the experiencing they were sharing with their remote partner. This can create safety issues.

Second, they may also want to be able to 'escape' the shared experience for short time periods to 'do their own thing' without interruption from a remote partner. Both of these issues suggest that selective availability of a video and/or audio feed is important. It also reveals that remote partners may experience a situation differently—one may want to talk and one may not. We had assumed that 'always-on' video and audio would be desired by participants throughout the activity, yet our study revealed that this may not be the case. Together, this highlights the importance of supporting asymmetrical experiences and being able to easily move into and out of contact with the remote person while not detracting from the close intimacy that was highly valued by many of our participants. Research on media spaces in the workplace similarly points to the value of asymmetrical experiences [32].

Third, we also found that when a person interacts with someone else at his or her location in the 'real world' the intimacy of the experience with one's remote partner breaks down. This can be disconcerting and even emotionally distressing for the person 'left out.' We feel this arises because the remote participants have only a minimal representation or embodiment at the remote location, e.g., a small video feed on a smartphone. People at the remote location cannot easily see them and nor are they able to easily interact with them. This suggests new opportunities

for designing for remote embodiments, if one wants to create an experience where interactions with other people in the surrounding environment are possible.

These findings also reveal that 'shared geocaching' and other similar activities likely work best in a paired situation. Engaging in parallel experiences with two people at a single location while another person is remote would certainly isolate the remote participant and create feelings of presence disparity (previously defined for workplace and classroom settings [30]). Similarly, having more than two people participate in a parallel experience where all are in different locations would also create large challenges in understanding whose video to look at and when.

Video Streaming in Public Settings

More generally, our study also explored the use of video streaming in a variety of public settings, e.g., a mall, parking lot, an adjacent plaza, and an urban park. None of our participants commented on privacy issues as it related to audio streaming, likely because of the prevalence and accepted understanding of using mobile phones in public settings. Despite knowledge of potential issues, most participants did not feel there were problems with streaming video from these locations. This was because the camera was streaming and not recording, or people felt local laws allowed them to stream video without consequence. Yet there are clearly issues.

First, the camera we used did not provide feedback that differentiated streaming from recording, which is clearly a design limitation. If they noticed the camera, bystanders had no understanding of whether they were being captured or streamed, and, if streamed, who they were being streamed to. The remote viewer was completely disembodied in the physical space of his or her partner [1]. These observations clearly suggest design opportunities for feedback mechanisms and remote embodiment.

Second, only one of our participants actually knew what the local laws were about capturing video in a public setting. The rest of our participants were operating under an assumption that it was okay without any real knowledge. Related to this, we also learned that locations are not always clear-cut in terms of what is private and what is public space. Shopping malls may feel like public places to people, yet they are actually private property and may come with their own distinct set of rules. Thus, there is easily a disconnect between the perception of a place and the actual rules that govern it. The design implications of how to address this are less clear, though it points to important considerations for video streaming technologies.

Third, we also recognize that if one were to design privacy-preservation solutions for situations such as video streaming in public settings, the paradigm of such solutions would need to be different than traditional privacy-preservation techniques for video communication systems. Historically, research on privacy in media spaces has looked at obfuscation techniques to mask what is being shown while still presenting some degree of information [3]. In workplace and home settings, this might mean 'blurring' out a person's image or their background. Yet in the case of public settings, the reverse needs to happen. Instead of masking out the person using the video (because she is likely behind the camera lens), privacy preservation strategies will need to think about masking out particular aspects of the user's view, be it other people or parts of the environment.

Applications and Future Work

We can imagine that these themes and implications might generalize to a number of applications beyond geocaching. Given the similarity between geocaching and activities like walking, hiking, and sightseeing, we believe this research could closely inform the design and evaluation of mobile-to-mobile video streaming for other outdoor recreational activities. Our findings may also extend to more diverse domains like search-and-rescue or jobsite inspection. However, this would need to be verified with further study. It would likely be the case that the importance of the themes we discovered would vary from application to application. For example, in a life-or-death scenario like search-and-rescue, safety issues would likely be crucial while privacy issues would be much less important. We believe the issues we have raised around privacy, safety, navigation, and 'micro' shared experience can act as lenses of investigation for this future work.

Limitations

We recognize that, overall, our demographic was relatively young and this may have an effect on our results in terms of people's acceptance of video streaming in public settings. That said, we did not see any obvious differences in opinions and usage between our younger and older participants. Nonetheless, future work should explore the different perceptions of video streaming in public settings with broader demographic samples. Our research also focuses on the participants' overall high-level experience of shared geocaching. Because we did not observe participants in the field, we were unable to obtain observation data that might have provided an objective perspective on the activity. We believe our interview method provided sufficient insight into the participants' experiences, but future researchers may want to find a way to observe or record participants' activities in the field. This kind of observation could illustrate things like how long or how often participants utilize the video feed.

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REFERENCES

1. Ames, M. G., Go, J., Kaye, J. J., & Spasojevic, M. Making love in the network closet: the benefits and work of family videochat, Proc. CSCW, ACM Press (2010).

2. Bellotti, V. Design for Privacy in Multimedia Computing and Communications Environments, in *Technology and Privacy: The New Landscape*, MIT Press (1998) 63-98.
3. Boyle, M., Neustaedter, C., and Greenberg, S. Privacy Factors in Video-based Media Spaces, *Media Space: 20+ Years of Mediated Life*, Springer (2009).
4. Brubaker, J., Venolia, G., and Tang, J. Focusing on Shared Experiences: Moving Beyond the Camera in Video Communication, *Proc. DIS,* ACM Press (2012).
5. Buhler, T., Neustaedter, C., and Hillman, S. How and Why Teenagers Use Video Chat, *Proc. CSCW,* (2012).
6. Chavez, D.J., Courtright, R., and Schneider, I. Over the River and through the Woods, *Parks & Recreation,* 39, 4 (2004), 68-72.
7. Chavez, D.J., Schneider, I., and Powell, T. The Social Psychology of a Technology Driven Outdoor Trend: Geocaching in the USA, *Proc. HICSS 2004*, ACM Press (2004).
8. Consolvo, S., Everitt, K., Smith, I., Landay, J. A. Design Requirements for Technologies that Encourage Physical Activity, *Proc. CHI*, ACM Press (2006), 457-466.
9. de Sá, M., Shamma, D.A., Churchill, E.F. Live mobile collaboration for video production: design, guidelines, and requirements, Personal and Ubiquitous Computing, Springer (2013).
10. Engström, A., Zoric, G., Juhlin O., and Toussi, R. The mobile vision mixer: a mobile network based live video broadcasting system in your mobile phone, Proc. Mobile and Ubiquitous Multimedia (MUM '12).
11. Inkpen, K., Du, H., Roseway, A., Hoff, A., and Johns, P. Video Kids: Augmenting Close Friendships with Asynchronous Video Conversations in VideoPal, *Proc. CHI,* ACM Press (2012).
12. Inkpen, K., Taylor, B., Junuzovic, S., Tang, J., and Venolia, G. Experiences2Go: Sharing Kids' Activities Outside the Home with Remote Family Members, *Proc. CSCW,* ACM Press (2013).
13. Judge, T.K., and Neustaedter, C., Sharing Conversations and Sharing Life: Video Conferencing in the Home, *Proc. of CHI,* ACM Press (2010).
14. Judge, T.K., Neustaedter, C. and Kurtz, A., The Family Window: The Design and Evaluation of a Domestic Media Space. *Proc. CHI*, ACM Press (2010).
15. Judge, T.K., Neustaedter, C., Harrison, S., and Blose, A., The Family Portals: Connecting Families Through a Multifamily Media Space. *Proc. ACM CHI*, (2011).
16. Kelley, M.A. *Local Treasures: Geocaching across America.* Santa Fe: Center for American Places (2006).
17. Hutchinson, H., Mackay, W., Westerlund, B., Bederson, B., Druin, A., Plaisant, C., Beaudouin-Lafon, M., Conversy, S., Evans, H., Hansen, H., Roussel, N., Eiderbäck, B. Technology probes: Inspiring design for and with families, *Proc. CHI,* ACM Press (2003), 17-24.
18. Mueller, F., O'Brien, S., and Thorogood, A. Jogging over a Distance, *Proc. CHI,* ACM Press (2007).
19. Mueller, F., Vetere, F., Gibbs, M., Edge, D., Agamonlis, S., and Sheridan, J. Jogging over a Distance Between Europe and Australia, *Proc. UIST,* ACM Press (2010), 189-198.
20. Mueller, F., Agamanolis, S., and Picard, R., Exertion interfaces: sports over a distance for social bonding and fun, *Proc. CHI,* ACM Press (2003), 561-568.
21. Neustaedter, C. and Judge, T. Peek-A-Boo: The Design of a Mobile Family Media Space, *Video Proc. Ubicomp*, Springer (2010).
22. Neustaedter, C., and Greenberg, S., Intimacy in Long-Distance Relationships over Video Chat, *Proc. CHI,* ACM Press (2012).
23. Neustaedter, C., Tang, A., and Judge. T, The Role of Community and Groupware in Geocache Creation and Maintenance, *Proc. CHI 2010,* ACM Press (2010).
24. O'Brien, S., and Mueller, F. Jogging the Distance, *Proc. CHI,* ACM Press (2007).
25. O'Hara, K. Understanding Geocaching Practices and Motivations, *Proc. CHI 2008,* ACM Press (2008).
26. O'Hara, K., Black, A., Lipson, M. Everyday Practices with Mobile Video Telephony, *Proc. CHI*, ACM Press (2006), 871-880.
27. Raffle, H., Ballagas, R., Revelle, G., Horii, H., Follmer, S., Go, J., Reardon, E., Mori, K., Kaye, J., and Spasojevic, M. Family story play: reading with children, *Proc. CHI,* ACM Press (2010).
28. Salovaara, A., Johnson, M., Toiskallio, K., Tiitta, S., and Turpeinen, M. Playmakers in Multiplayer Game Communities, *Proc. ACE 2005*, ACM Press (2005).
29. Stanley, K., Livingston, I., Bandurka, A., Kapiszka, R., Mandryk, R. (2010) PiNiZoRo: A GPS-based Exercise Game for Families, *Proc. Future Play,* (2010), 276-279.
30. Tang, A., Neustaedter, C., and Greenberg, S. Embodiments in Mixed Presence Groupware, *British HCI,* ACM Press (2006).
31. Virtual Photo Walks, www.virtualphotowalks.org
32. Voida, A., Voida, S., Greenberg, S., and He, H. A. Asymmetry in media spaces, *Proc. CSCW,* (2008).
33. Yarosh, S., Cuzzort, S., Mueller, H., and Abowd, G.D., Developing a Media Space for Remote Synchronous Parent-Child Interaction, *Proc IDC*, ACM Press (2009).
34. Yarosh, S., Inkpen, K., and Brush, A.J., Video Playdate: Toward Free Play Across Distance, *Proc. CHI,* ACM Press (2010).