Designing Outdoor Remote-Communication Tools for Serious Collaborative Activities

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Abstract
We are seeing increasingly widespread usage of remote communication, and in particular video communication, for outdoor activities such as tours, shopping, and searching large environments. However, current technologies still do not provide sufficient awareness to remote communicators or sufficient means for them to indicate their intents or contribute to collaborative activities meaningfully. We describe some of the work that we have done in the past to study the challenges that people face in remote communication in the outdoors, and to design technology solutions that aim to address those challenges. We also describe our current work to address such challenges in the domain of wilderness search and rescue (SAR).

Author Keywords
Remote collaboration; video communication; outdoor activities; serious tasks; search and rescue

Introduction
Video-communication tools, like Skype and FaceTime, are becoming increasingly widespread, and there is a growing interest in using them in the outdoors [4–6,8,12]. Examples of outdoor uses include shopping [6,8], watching kids' sporting events [4], taking a

Figure 1: A mobile-video-communication scenario where one communicator (left) is moving around outdoors and another (right) is communicating from a remote stationary location.

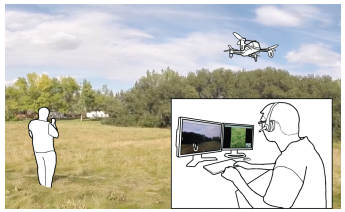

Figure 2: Mobile video communication utilizing a drone.

friend on a tour [6,8,10,12], laying out objects in a field [5], and searching large environments [5].

Our research interests involve understanding the communicative, collaborative, and awareness needs of people engaged in remote communication in the outdoors while taking part in serious activities; and designing technologies that address those needs. For the lead author's PhD thesis work, the focus is particularly on the context of wilderness SAR, which involves the search for and extraction of one or more subjects from a wilderness area.

Past Work

Understanding Communicative Intents in Mobile-Video Camera Work: In the past, we have explored how phone cameras are used in video chats to support communicative intents in collaborative activities in large spaces (Figure 1) [6]. The activities we studied include giving a tour, going shopping, and selecting from meal items in a food court. We found that while collaborators use the phone camera in a variety of ways to support specific intents, remote collaborators (i.e., those who are not in the space where the activity is focused) faced challenges in fully understanding and attaining sufficient awareness of the scene to effectively contribute to the activity at hand. In standard mobile video communication, remote communicators have to rely on a camera view that is shaky, has a low field of view (FOV), and is out of control of the remote communicator. This creates challenges in, for example, effectively making comparisons or connections between things in the activity space. For leisurely (or 'shared-experience' [1]) activities, such as taking a friend on a tour, a remote friend may not be able to feel as much a part of the activity as the person in the local space, as the remote friend is unable to directly manipulate her view and control her experience. This lack of control could make the remote friend feel like she is missing out [4,6,9]. This issue means another thing for more serious tasks like search and inspection (e.g., SAR, worksite inspection). In these cases, this lack of control means that remote collaborators cannot effectively see or perceive things in the space that the local collaborator cannot, thus making the remote collaborator effectively useless and unable to assist in a meaningful way [6].

Another challenge is in remote communicators being able to effectively give instructions to those in the local space. For example, in moving around and navigating a space [5,6], remote communicators may have difficulty telling their partners exactly where to go [6]. In moving and manipulating objects [3,6], remote collaborators may have difficulty telling their partners which way to orient and position an object [6].

Interfaces for allowing a remote person to contribute to outdoor collaborative activities would have to address these issues. In particular, in SAR, remote collaborators would need to have a sufficient understanding of the layout of the search environment, as well as the objects and people contained within it [7].

Drones for Video Communication: We have also explored the use of drones for mobile video communication, where one collaborator is in an indoor setting (such as an office) and another is outdoors with a smartphone and a drone (Figure 2) [5]. The activities we explored include laying out objects in a field (akin to setting up a park for an event) and searching and inspecting items in the outdoors (akin to tasks such as

Figure 3: Wilderness-SAR groups around the world are beginning to use drones to assist with search tasks.

SAR). We found that giving the remote collaborator a view (through the drone) that he/she can control from a unique perspective independent of that of the local collaborator can allow the remote collaborator to see things that the local may not see. In a task like SAR, viewing into the environment from different perspectives and scales could potentially increase the likelihood of spotting a subject, as the subject could easily be visible from one angle and unnoticeable from another. While there are potential benefits of using a drone for video communication, we also uncovered challenges with regards to controlling the drone, matching visual information between camera views, and translating navigational instructions to the frame of reference of the local collaborator.

Current Work: Search and Rescue

In addition to the communication and collaboration challenges and opportunities outlined in our previous research, we also aim to understand the unique challenges that wilderness-SAR workers face in their day-to-day work, and from that flesh out the opportunities for remote-collaboration technologies to support wilderness-SAR team collaboration.

In much of the world, wilderness SAR is carried out by teams of workers. For a typical scenario, team members will be paged to meet at a command post, which is a trailer parked at a location near the search area [7]. The command post contains work desks, communications equipment, outdoor tools, maps, whiteboards, food, water, and other necessities. Depending on the scale of the search, members will form either one or multiple field teams, and each team, which contains one leader and multiple members, will move around, scan, and search the area they are tasked [7]. Field workers may have to deal with conditions such as rough terrain, nighttime lighting, rainstorms, blizzards, and strong rapids, while at the same time carrying lots of equipment. The SAR manager, who works from the command post, plans the search, coordinates the teams, and ensures the safety of everyone [7].

We are currently conducting an interview study to understand the work processes of wilderness SAR workers, the procedures they follow, their communication methods, the tools they use, the challenges they face, and the factors that lead to success or failure in SAR missions. Our goal is to attain an understanding of the personal experiences of SAR workers during past real-world incidents, as well as their perspectives of the challenges they faced during these incidents. So far, we have conducted one-hour interviews with three participants, including one team leader and two team members.

Our early results so far have indicated three themes of design implications for remote communication and collaboration tools for wilderness SAR:

1. Design technologies to help management build a bigger-picture awareness of teams and team members' activities and statuses. SAR managers need to build and maintain a bigger-picture awareness of a search incident. As a search goes on and more people become involved, this bigger picture becomes more difficult to maintain, and the potential for logistical errors increases. For example, location, status, and activity awareness of SAR teams and team members is a challenge. A simple design solution could involve, for example, automatically collecting and

aggregating incoming information from field teams and specific locations (such as photos, videos, notes, and GPS coordinates of workers), and presenting them to management via map overlays on large displays.

2. Design technologies to allow field workers to effectively share and receive information relevant to them. Field workers are concerned only about information that is relevant to them, and thus communication and collaboration technologies designed for field workers should present only information that is relevant to them. There exist opportunities for technologies to cleanly present objectives and statuses to field workers in relation to the bigger picture, so field workers can see their work in relation to its contribution to the overall search.

3. Design technologies that do not detriment the situation awareness of field workers. SAR field workers need to be constantly aware of their surroundings, and they need to have their hands free to use tools and move objects. Any technologies that field workers use should keep all of this in mind, and allow field workers to communicate, send, and receive information hands-free and with few distractions. Technologies such as head-mounted displays and wearable cameras are possible solutions.

Future Work

We plan to conduct more interviews, including interviews with SAR managers, to further understand SAR communication challenges and technology needs, as well as to brainstorm technology-design ideas with them. In addition, we also plan to observe SAR teams conduct training activities and mock searches, from the perspective of both the command post and the field locations. Here, we hope to see first-hand the actions that SAR team members take to communicate with each other and coordinate their actions, as well as to see first-hand the challenges they face in doing these things. We will observe the specific actions and procedures that SAR workers take to understand the situation, coordinate their activities, and communicate with their team members. We will also be observing when these actions succeed and fail.

To address the challenges and design opportunities that come up from the interview and observation studies, we also plan to iteratively design and implement prototypes for remote-communication and collaboration tools for wilderness SAR, taking a research-through-design approach [2,11] in doing so. We plan to work closely with SAR workers in designing the tools, and we will seek regular feedback from them which will guide the next iterations of our designs. Throughout this co-design process, we will discuss with SAR workers to understand how SAR work practices would have to change to adapt to new technologies.

We also plan to formally evaluate the more-refined prototypes we design through two stages: (1) field simulations with non-SAR participants performing semi-controlled outdoor team activities related to SAR scenarios, and (2) long-term deployments with SAR teams for SAR training activities and mock searches.

Alongside the implications for wilderness SAR, our work will also push the boundaries of remote communication into demanding outdoor situations involving team collaboration, possibly benefiting other serious domains such as firefighting and disaster response.

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