Teledrone: Shared Outdoor Exploration Using Telepresence Drones

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ABSTRACT
Outdoor activities are an important way for friends, family, and couples to spend time with one another and share exploration activities. Yet when people become separated by distance it can be difficult if not impossible to participate in outdoor activities together. We propose a design called Teledrone that uses a drone with video conferencing display to create feelings of social presence during shared outdoor activities over distance. With Teledrone, users connect into the video call display and can maneuver the drone to follow a friend or family member during an outdoor activity such as hiking. In this way, Teledrone provides an embodiment for a remote user and can help support spatial awareness.

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Telepresence; drones; outdoor activities

1 INTRODUCTION

Outdoor activities can be an important way for friends, family, and couples to spend time with one another and share exploration activities. Moreover, people often share such activities as a form of motivation, socialization, and fun for exertion activities [1]. However, with the increase in globalization, family and friends are finding it increasingly hard to be able to participate in outdoor activities together as they are often separated by distance [2]. Research has explored various solutions for supporting shared activities over distance, including wearable cameras and telepresence robots. Yet wearable systems lack an embodiment for the remote user [3,4] and telepresence robots can be challenging to use in outdoor environments [5, 6].

One way to solve such challenges in the context of outdoor activities could be by employing a telepresence technology that does not require hands-on navigation. For example, previous research has been done on the use of unmanned aerial vehicles (UAV)—drones—with predetermined paths to accompany people in outdoor activities such as jogging [7]. Explorations of the use of spatialized audio in outdoor activities have shown that it can help create valued social experiences [8]. In this paper, we describe our system, Teledrone, for connecting pairs of people over distance to participate in shared outdoor activities.

2 RELATED WORK

A large amount of research has been done on the use of telepresence technologies for creating social presence. While there has been relatively less research in the context of outdoor activities, we draw inspiration from a number of prior works.

Firstly, research has been done on the themes of embodiment, control, personality, and communication in outdoor exertion activities with a "flying robot" companion [5]. A study with this flying robot showed that users appreciated the "embodiment" of the robot. Some users preferred to be in control of the robot while others were interested in the robot leading the activity. Additionally, research has been done on the use of spatialized audio for creating social presence in shared outdoor activities [8]. A study shows that this can be a very effective way of sharing exertion activities such as jogging, with some participants even preferring it over collocated shared jogging.

Another area that has been explored is the use of robot-mediated presence in public areas for outdoor activity sharing, including geocaching [5]. Study results found that participants valued the social presence created by the telepresence robot, yet it was sometimes challenging to do specific tasks with the robot. This reflects the broader research around telepresence robots, which shows challenges with spatial orientation and interactions [9,10].

Researchers have also explored the use of mobile video in the outdoors. For example, one study investigated the use of a camcorder on a tripod for sharing kids' activities with remote family members and found that people appreciated being able to share these experiences, but there were challenges with mobility and embodiment [11].

Overall, we see the desire by people for sharing outdoor activities over distance, and challenges

Figure 1: The design of the Teledrone body

Figure 2: The video stream, as seen by the remote user

Figure 3: The design of the spatialized audio headset

with the existing set of design solutions that researchers have tried. For this reason, we have continued explorations of this design space by looking at design solutions that combine attributes of telepresence robots with drones.

3 THE DESIGN OF TELEDRONE

We designed a telepresence drone called Teledrone with the goal of allowing remote family and friends to participate in an outdoor activity together. Next, we describe a usage scenario that illustrates the experience of using Teledrone:

Scenario: Jane is currently living in a different city than her friend Sam, but they want to spend time together over the weekends. Sam plans to go hiking, and traveling is not an affordable option for Jane. Sam takes Teledrone with him to the hiking trail, and Jane starts a video call. As Sam goes through the trail, the drone follows him, allowing Jane to share the experience.

3.1 Video Display

The Teledrone supports two-way video streaming over an internet connection. This was accomplished by attaching a small tablet device to the body of a DJI Phantom 4 Pro drone. The tablet facilitates the use of video through software such as Skype. The video call running on this device also provides a method of making the device a true representation of the remote user by showing them live on the display, similar to the design of most telepresence robots. In the future, a 360-degree camera can be used to give the remote user more control over what they see.

3.2 Automatic Navigation

In order to minimize the cognitive load of manually navigating through the drone's controls, which can distract from social connection, the Teledrone automatically follows the outdoor person at a close but safe distance. The outdoor user must carry the controller either by hand or, for example, in a backpack. We set the drone to follow the outdoor user such that the display is positioned around eye-level. The distance from the drone body to the outdoor user can be set by starting the Teledrone at the desired distance, which will be maintained throughout flight. Through several pilot testing trials, we found that the ideal distance at which the drone can safely be flown while still creating the sense of companionship is around 4-8 feet. Automatic navigation will allow the remote user to focus on the experience rather than being distracted by navigation.

3.3 Spatialized Audio

The video call running on the Teledrone tablet also includes a two-way audio stream. This is facilitated through a headset that the outdoor user wears. The headset spatializes the audio stream through custom software we developed. Thus, both users hear audio from the other person coming from the direction of that person in relation to the drone. This spatialization was accomplished by placing a RICOH THETA 360-degree camera on top of the outdoor user's headset, tracking the drone's relative position and panning the audio accordingly. With spatialized audio, we hope to create a sense of embodiment.

Figure 4: The Teledrone in use, pictured alongside the outdoor user

4 EXPLORATORY PILOT STUDY

We designed an exploratory pilot study in order to assess how well the Teledrone supports a sense of social presence and enjoyment in shared outdoor activities. Here, we present the findings.

4.1 Method

We recruited a self-selected pair of participants, including a mother (age 48) and son (age 24). At the end of the study, the pair were interviewed. We asked questions about their feelings of presence, understanding of location, approaches to collaboration, pros and cons of the shared connection and navigation, and how they felt about others on the trail seeing the Teledrone.

4.2 Pilot Results and Findings

The participants felt that the Teledrone afforded a sense of social presence, although in different ways for each participant. In the interview, P1 (outdoor) explained that when taking the selfie, "it seemed like he was beside me". P2 (indoor) felt that "I didn't feel like she was present with me like in my room, but I sort of felt like I was there". This was not unexpected, as the sense of *outdoor* presence is the focus of the design.

Localization and spatial awareness were found to be effective through the Teledrone, and the shared connection played an important role in this. P2 elaborated, "it was a lot better than expected because I was paying more attention in the pathfinding part than I usually do". P1 agreed, adding that "audio was good too, because I could say 'which way now' and [P2] said 'go left'".

Regarding the automatic navigation of the Teledrone, P2 explained that "it was really cool and fun, like I was a bird flying along". However, P1 expressed a sense of distrust, saying "It was so loud and scary and I can't read its mind to know where it will go, maybe in my head and I get hurt". While the Teledrone was programmed to stay at a safe distance, the participants were unused to the sound of the propellers.

P1 also felt somewhat uncomfortable when others walked by, explaining "I felt weird and taking too much attention". When asked to explain this further, she suggested that this feeling was due to the novelty and uncommonness of the technology. P2 did not share this concern.

5 DISCUSSION AND CONCLUSIONS

The Teledrone design describes a platform that aims to allow people to share outdoor activities in a remote manner, creating a way for family, friends, and couples to spend time with one another over distance. Our design brings to light an important area for further development, as we recognize that it could be improved to include better functionality for sharing outdoor experiences with a group of people. Our pilot study revealed the potential for people to feel closer, as though the remote person was 'beside them'. However, the automatic navigation raised questions related to perceived safety. Future research and evaluation should assess the efficacy of telepresence drones in a broader set of distributed outdoor exploration activities, and expand and hone the functionality, as well as exploring any behaviors or limitations that arise.

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