
360° View for Sharing a Geocaching Experience with a Telepresence Robot

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Abstract

People often enjoy sharing outdoor activities together such as walking and hiking. However, when family and friends are separated by distance, it can be difficult if not impossible to share such activities. We explore this design space by investigating the benefits and challenges of using a telepresence robot to support outdoor leisure activities. In our study, participants partook in the outdoor activity of geocaching, where one person geocached with the help of a remote partner via a telepresence robot. We investigate the usage of a telepresence robot equipped with a 360° camera attached, to stream video to a virtual-reality (VR) headset worn by the remote user. In this paper we discuss the social experience of participants using VR to experience the remote location.

Author Keywords

Telepresence robots; video communication; virtual reality; social presence; geocaching; leisure activities

CSS Concepts

- Human-centered computing ~Human computer interaction (HCI)~HCI design and evaluation methods ~User studies

Introduction

Friends and family members often enjoy participating in shared outdoor activities together [10,11]. This can range from simple activities like walking or hiking, to

more complicated sports like soccer. When people are separated by distance, such shared activities become more limited, if not impossible. As such, researchers have explored ways of supporting shared activities over distance through mobile video communication [3,15].

Different studies have focused on usage of mobile video chat in the outdoors, and have identified challenges such as lack of immersion [5] and lack of embodiment leading to awkward social interactions [14]. To address these issues, we explored the use of telepresence robots as part of outdoor shared activities over distance. Telepresence robots have been studied in a myriad of contexts where researchers have noted the benefits of providing a mobile video conferencing solution with a representation of a 'physical body' in the remote space (e.g., [12,16,18]). Despite this work, we have yet to see telepresence robot usage explored as part of outdoor leisure activities shared over distance.

In our study, two users participate in the activity of geocaching, where one operates a telepresence robot from a remote indoor location. Geocaching is an outdoor treasure hunt game where players search for hidden containers in parks or urban areas using GPS coordinates or maps [11,13]. We selected geocaching as our focal activity because it contains several basic actions within it, including walking, conversing about the environment, navigating to specific locations, and searching for objects (often found in sightseeing) [14].

For half of our study, a 360° camera attached to the top of the telepresence robot streamed video to the remote user, allowing them to immerse themselves in the outdoor environment in virtual reality (VR). For the other half, as comparison, the remote user operated

the robot through its regular wide field of view (WFOV) cameras and normal control interface. Our research was exploratory, and the full results of this study can be found in [2]. In this workshop paper we focus specifically on the usage of the 360° view in VR, and how the social experience was for the remote user wearing the virtual reality (VR) headset to immerse themselves in the remote location.

Related work

Telepresence robots offer a form of mobile video communication and bring the added benefit of autonomy to the remote user, who is now able to move around the environment. Telepresence robots have been found to increase one's sense of presence in remote workplaces, and allow users to feel a better sense of social connection with their remote colleagues [9]. We explored 360° camera usage coupled with a telepresence robot. 360° videos offer one solution to the narrow field of view that normally comes with video communication systems. 360° videos can be viewed using head-mounted displays (HMDs) as well as tablets. Using an HMD has been shown to lead to stronger feelings of immersion and emotional investment in the remote location [1]. Studies on 360° video show that using such technologies for exploring a new location can allow remote users to experience the location independent of the local person [6-8,17]. Using 360° video views with telepresence robots in indoor settings has also shown increases in task efficiency, but was more difficult to use for participants [4]. It can also be difficult for the remote and local users to understand directions and orientation in 360° views (e.g., understanding where the other person is looking in the 360° view) [17]. Users also lack mechanisms to gesture and point at things in the environment [17]. In

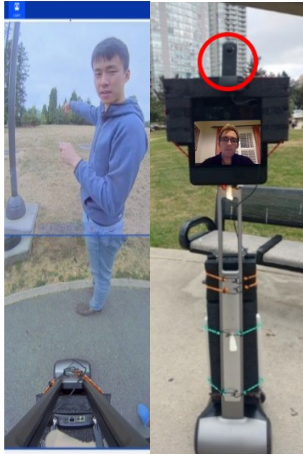


Figure 1: The Beam interface (left) and robot with 360° camera attached to the top (right).



Figure 2: The VR view of the 360° live-video feed, as it was presented to the viewer through the smartphone-VR setup

this paper we report on how remote participants immersed themselves in the distant environment while being able to control both their viewpoint and physical embodiment in the environment through the telepresence robot. From this, we discuss some of the social experiences and improvements needed for such technologies.

Study

We recruited 14 pairs of participants (4 Female-Female, 8 Male-Male, 2 Female-Male) within an age range of 19 to 39 years ($M = 24$) through snowball sampling. All participants knew each other before the study. We used a Beam+ commercial telepresence robot (hereafter called a Beam). The robot was 134.4 cm tall and consisted of three wheels, a gray body, and a 25.4 cm monitor displaying the face of the remote user (Figure 1). A forward-facing camera and microphone are embedded in the monitor for streaming video and audio. A downward facing camera below the display faces the ground to help the user navigate in the environment. For safety and to prevent damage, we affixed Styrofoam around the Beam's screen. In this paper the remote participant is called the Beamer, and the person in the park is called the Explorer.

We attached a Ricoh Theta S 360° camera to the top of the Styrofoam protecting the Beam (Figure 1, right, circled in red) and connected it to a MacBook Pro laptop attached to the Beam's base. The laptop streamed the live 360° video from the camera to a remote viewer via WebRTC. The resolution of the streamed video (which included the entire 360° view) was 1280x640 pixels. The Beam and laptop were connected to a mobile hot spot with a 4G/LTE cellular signal. Participants drove the Beam using a PlayStation-3 controller within a

desktop application on an iMac computer with a Dell P2417H 60cm-wide 16:9 monitor in portrait orientation; thus, the screen was 60cm tall and 33.8-cm wide. The 360° video was displayed on a Nexus 5X smartphone set to a Google-Cardboard VR configuration and placed inside a Xiaozhai I plastic headset case worn by the user. A white semitransparent arrow was overlaid onto the 360° view in the VR configuration, to indicate which direction was forward in relation to the Beam (Figure 2).

For the activity, both participants were given a paper map of the park with flags indicating the location of four geocaches. Participants were asked to complete the task together as a team. The geocaches were hidden in an urban park consisting of asphalt walkways, trees, benches, tables and fountains. Geocaches were placed in locations where it was easy for both the Beam and the Explorer to reach (e.g., within a foot of the walking path). The pair's mission was to find all of the geocaches in 45 minutes. The Beamer used the 360° camera setup for two geocaches, and the regular WFOV Beam camera for the remaining two. We counterbalanced which geocaches each pair found within the two different camera setups. We also counterbalanced the ordering of the two camera setups so that half of the pairs used the 360° camera first and half used the regular Beam cameras first.

Results

Although the robot was more difficult to control in VR and the resolution of the camera was lower, our participants enjoyed the experience of the 360° view, since they felt immersed in the environment. Beamers also enjoyed being able to look around while driving, and changing their viewpoint just by moving their head.

Some Beamers felt that this was more natural than needing to turn the robot every time they wanted to see something behind or to the side of it. Sometimes they were so immersed that they forgot about the location they were actually in, and the fact that they were behind a desk.

"In the 360° view, I felt more realistic. Whereas in the regular view, it just felt really flat. I still feel like the regular view was easier to [control] just because you could see the bottom. Instead of the single arrow, it was [guide-] lines [guiding the robot's movements]. So, it was easier to direct yourself" –P3Beamer

When the Beamers were in VR, they desired to have some sort of body language beyond just the mobility of the robot, as they wanted to have greater ability to point, gesture, and non-verbally express themselves in the environment. The Explorers also wanted to know where their Beamer partners were looking. Even though the Beamer's face could normally be seen on the screen of the robot, the Explorer could not actually see their expressions when the Beamer was wearing the VR headset, as their face was covered. They could only infer where they might be looking based on their head orientation.

"If I could somehow also see what [P10Beamer] was seeing, [P10Beamer]'s point of view, on the screen, [that might help]. This didn't feel a problem because we both are in the proximity of each other" – P10Explorer

While the Beamer was in VR, they were sensitive to movements of the camera and drove more slowly. Due

to this slow movement, they got a chance to look around and experience the remote location more.

"...because the driving was slow, [I was able to look around more...] Looking around, [it] was just cool to see what's around me because I have control of what I want to see, so in a way it felt more real, because in real life, you can always look around and keep walking forward." –P5Beamer

Another situation when Beamers were not completely comfortable in VR was when the robot went off track or fell, and one of the researchers or the Explorer needed to drag it to the correct position. They mentioned such quick movements that they did not control made them feel uncomfortable.

"If your view changes fast, you will be shocked with the slight motion sickness, because you don't move, but the view changes fast... – P1Beamer

Conclusion & Discussion

We studied the usage of 360° cameras on telepresence robots for sharing leisurely activities like geocaching outdoors. We focused on geocaching as an exemplar activity as it contains a variety of basic activities within it, including walking/hiking, conversing, and looking for specific objects (similar to sightseeing). We found that by having the Beamer operate the robot in VR, they felt immersed in the remote location. However, issues such as difficulty driving the robot, motion sickness, and slow speed detracted from the activity. Also, due to use of the HMD, the Beamer's facial expressions were hard to read. New methods of conveying emotions should be studied, and better guiding techniques should be used for this type of technology.

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