Towards Hybrid Presence Enabled by Indoor Localization and Holograms

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In this work, we explore ways to make hybrid conferences appear seamless and natural by merging the virtual- and the real-worlds. We use ultra-wideband UWB localization to insert “avatars” of real participants in the virtual space, and holographic projections to make virtual participants appear present in the real-world.

Additional Key Words and Phrases: Indoor localization, UWB, Hybrid Conferences

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1 INTRODUCTION

Social interaction is human nature. We make friends, share emotions, and communicate thoughts and information through daily interaction with other people. However, the COVID-19 pandemic has made travel, in-person social interactions, and in-person meetups and conferences, very limited. This is exemplified in how research conferences are held today with in-person attendance optional and by adding virtual components so that those who cannot travel or choose not to, can still participate. While people find hybrid conferences inconvenient and difficult to manage, we must also acknowledge several benefits that hybrid meetings bring: (1) They are better at democratizing conferences since more people can attend when the costs are lower, (2) They reduce the uncertainty of attendance introduced by flight delays or unpredictable local weather events. (3) Virtual participation decreases the carbon footprint from conference travel. Keeping in-person participation low would be a viable approach to make future academic conferences "green conferences". Given these advantages, we believe hybrid conferences and meetings are likely to remain rooted for the foreseeable future. Therefore, we feel compelled to provide a technological venue to empower hybrid conferences where virtual and onsite attendees can have near-natural conversations, including round-table discussions, and small talks in the hallway. With enriched social opportunities, we envision attendees to have less overhead making personal decisions about protecting the environment while fully relishing the delight of intellectual exchange.

With current technology, the paper-presentation component of a conference can be handled reasonably well in hybrid conferences since there is a dedicated speaker, a dedicated spot where the speaker is stationed, and a dedicated view of the presentation that needs to be live-streamed to the virtual attendees. However, some of the best interactions in conferences occur during breaks between paper presentations and during social events such as lunches and banquets. In this work, we explore how we can include virtual participants in these social events without hindering the experience

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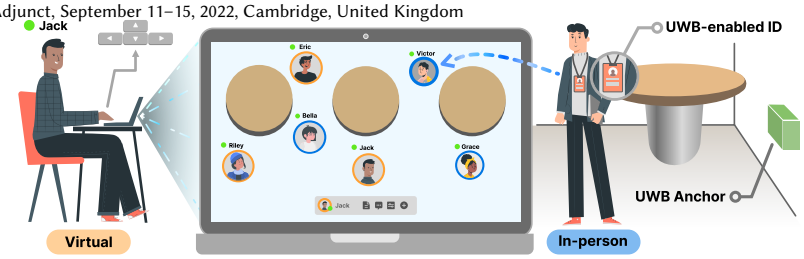

Fig. 1. Real world participants appear in the virtual space. Their location is tracked using UWB localization as they move around in at the conference venue. Virtual participants use arrow keys to navigate the virtual space.

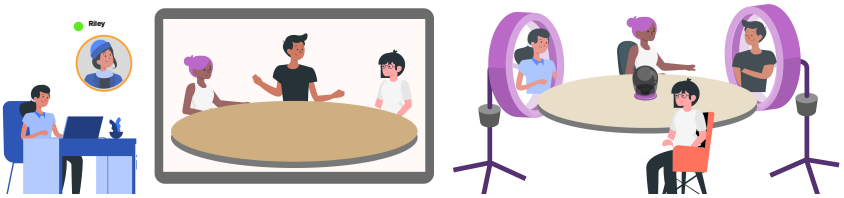

Fig. 2. Virtual participants view a seamless table spanning in-person and virtual participants, captured using a 3D camera in the real-world, and transparent background for the virtual participants. Virtual participants appear 3D, using hologram fan projections.

for the in-person attendees. Though we do not have actual implementation of the proposed ideas, we describe the path to realizing those ideas and hope to encourage scholarly discussion on the topic, through this work.

A convenient tool for fully virtual conferences is interactive virtual spaces such as gather.town [3] where the conference organizers setup a virtual arena like a computer-game. Each person is represented by an "avatar" that others see, and the participants use arrow controls on their keyboards to direct the "avatar" throughout the virtual arena. Most interestingly, virtual participants hear and see other participants only when they are in close proximity. Gather.town thus attempts to mimic real-world interactions where only people in close proximity generally talk with each other. When all participants are virtual, this mechanism works well. However, when catering to hybrid conferences where several participants are present at the venue in real-life, integration of the real-life with a virtual gather platform becomes challenging. We now discuss our seamless hybrid presence approach using indoor localization and holograms.

2 DESIGN OVERVIEW

We have identified several key challenges which should be overcome to make the hybrid experience seamless: (1) Representation of real-world participants in the virtual world; (2) Representation of the virtual world participants in the real world; (3) Real-Virtual audio exchange; (4) Real-Virtual video exchange; (5) Round table conversations; and (6) Walk-through experience for virtual participants.

2.1 Representation of real-world participants in the virtual world

Assume that the conference organizers create a virtual gather.town-like room that exactly mimics the conference venue; the locations of tables and chairs in the virtual world mimics those in the real-world. Virtual participants can "move" around this virtual space using the arrow-keys, while in the real-world, participants can just walk across the room and sit at a table with empty chairs. We ask: *How will the virtual participants see the movements of the in-person participants?*

We propose a solution based on our recently developed ultra-wideband (UWB) based indoor localization technology [1], a mechanism which performs sub-meter localization, and simultaneously supports infinite users without any user data collection. In this poster, we imagine the conference venue to be instrumented with UWB anchors that perform two-way ranging between each other. All participants wear a special UWB-enabled ID which localizes itself

by passively overhearing the UWB two-way ranging message exchange between the anchors in the room. The ID periodically transmits its location to a wireless base-station. The base-station translates each participant's location to virtual space and renders an "avatar" in the virtual view (see fig. 1).

2.2 Representation of the virtual world participants in the real world

Location of the virtual participants can be mapped to the actual room's coordinates quite easily since the virtual coordinates are already known to the system. However, representing the virtual "avatar" in a physical room can be challenging. One possibility is to use life-sized robots as explored in the human-digital twin concept [4]. A robotic presence can be quite limiting, however, since it occupies real estate and a conference's organizers will have to accommodate both real participants as well as robotic ones, driving up the costs of the conference. Instead, we envision a low cost solution: ceiling mounted projectors that project virtual participants' photos or "avatars" on to the floor at the locations where the virtual participants are present.

2.3 Audio exchange between the virtual and real worlds.

Assume that all in-person participants are wearing earbuds. When the location of the in-person participants comes close to that of the virtual participants, an audio stream is enabled between the two. Thus, when walking close to an avatar image on the floor, an in-person participant can expect to naturally talk to the virtual avatar. We want to enable both the visual and audio presence of all attendees. New virtual attendees approaching will be "seen" as their avatars images on the floor approach the in-person attendees, and their audio feed will be slowly faded in. This representation prevents the feeling of sudden or jarring appearance of voices or unintentional intrusion, making the overall system quite natural for both in-person and virtual participants. At designated spots where video booths are available for the virtual participants, larger speakers and microphones allow earbud-free conversations.

2.4 Video exchange between the virtual and real worlds.

Video exchange between the virtual and in-person participants can be limited to certain designated areas. A simple means to enable such conversation is to have TV screens mounted on walls at certain spaces in the real-world where a group of virtual participants can be seen together, similar to video conferencing today. This facilitates interactions as in-person participants walk to these video screens.

2.5 Round table conversations

Longer sustained conversations happen at round tables. A couple of seats at a table might be reserved for virtual participants only. Virtual participants might choose to park their avatars at those spots in the virtual space. In the real-world, such designated seats will be equipped with hologram fans [2] creating a background-less video of the virtual participants (see fig. 2). The real-world participants at the table will be videographed using a 3D camera placed on the table, so that the virtual participants can see everyone at the table by panning their video view or zooming out. High-quality speakers and microphones at the table complete the round-table feel and experience.

2.6 Walk-through experience for virtual participants

We propose to use volumetric video cameras to capture every detail of the room and the virtual participants can enjoy a walk-through experience. Thus instead of a static 2D image of the conference venue, the virtual participants will see a 3D street-view style rendering of the conference venue with live people talking and moving. Volumetric video capture allows changing of camera view at will, for each virtual participant.

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