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# Absence Agents: Mitigating Interruptions in Extended Reality Remote Collaboration

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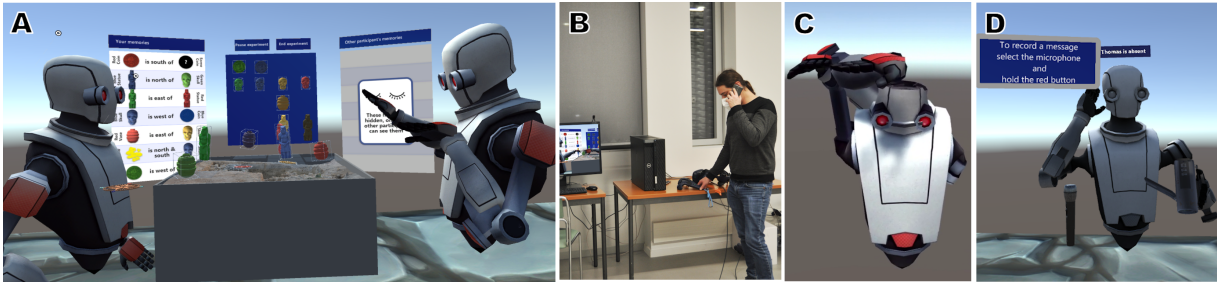


Figure 1: Two users collaborate remotely in Extended Reality (A). One of them gets interrupted by a phone call, causing him to put down his headset and controllers on a table (B), which results in an unnatural pose of his avatar (C). We address this and other problems through our novel concept: Absence Agents (D).

## ABSTRACT

Although dealing with interruptions in remote collaboration has been studied in general, few works have done this for Extended Reality (XR) collaboration. With the current explosion of interest in XR collaboration, we explore the negative impacts of interruptions in synchronous distributed XR environments and propose a novel concept for dealing with them: Absence Agents. We present their requirements analysis, design, and a prototype implementation. We believe that our concept and design of Absence Agents are important for practitioners and researchers alike, as they highlight avenues for future research.

**Index Terms:** Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Collaborative interaction

## 1 INTRODUCTION

With advances in Augmented Reality (AR) and Virtual Reality (VR) technology, collaborative eXtended Reality (XR) applications are becoming more mainstream. With the technology maturing, research can focus to a greater extent on supporting and enhancing collaboration [1]. Collaborative XR involves multiple people working towards the same goal using XR devices. This paper focuses on synchronous distributed collaboration in XR. In reality, users often collaborate remotely through emails, phone- or video calls. However, they are prone to interruptions – colleagues entering their office, receiving important mail that needs their attention immediately, or phone calls. Interruptions are inevitable in collaboration in general, but especially so during remote collaboration. Even when people collaborate simultaneously, interruptions create short-term absence. We consider short-term absence occurs between 1-15 minutes, the time it would generally take the users to deal with distractions.

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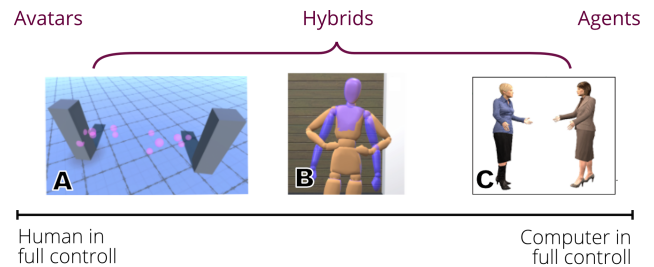


Figure 2: Avatar – Embodied-Agent Continuum for collaborative XR. A) Example of the computer augmenting eye contact of humans’ avatar [3]. B) The computer is controlling the avatar’s posture, the human is controlling the rest [5]. C) The computer is in full control of appearance and output and mediates every input of the human [4].

Our research explores Absence Agents: a new concept for mitigating interruptions in collaborative XR. We consider that for the design of the Absence Agents, one significant factor is the digital representations of the users and their Agents. Through these representations, they can interact with the world and be recognised in the shared scene. These representations can differ in the form and shape and can be divided into different categories: avatars, embodied agents, and hybrid forms [2]. Figure 2 visualises the Avatar – Embodied-Agent Continuum and details the relationship nuances that hybrid forms can have. We present in this paper our rationale, design, and a prototypical implementation of the Absence Agents using the hybrid forms (Figure 1).

## 2 ABSENCE AGENTS: DESIGN AND IMPLEMENTATION

### 2.1 Rationale

In a typical scenario, we envision a team of users meets in a remote XR environment using head-mounted displays. During the meeting, Person A, wearing VR glasses and working from home, is interrupted by their doorbell ringing. They need to take off the VR headset and controllers to see the real world, so they place them on the desk. Others see Person A’s avatar wobbling around during this process until it stops in an unnatural position. The team continues without Person A but must delay some decision as it needs unani-

Problems	Consequences for absentee	Consequences for those who stay behind
P1 Continuous Tracking	Little privacy during absence Displacement of avatar	Be distracted through audio and movement of absentee
P2 Missing Knowledge & Consent	Cannot share advice or objections Miss out on information due to the absence	Lack expertise of absentee Wait for absentee to return for critical issues or decisions
P3 Catching Up	Cannot jump into collaboration immediately Take in a bulk of information	Interrupt collaboration workflow

Table 1: Problems occurring because of short-term absence in synchronous remote XR collaboration.

mous agreement. Person B is wearing see-through AR glasses and works from the office. A colleague comes in and asks a question. Person B does not need to take off their headset to interact with their real environment. The others in the virtual scene see Person B talking, moving, and gesturing to someone they can not see. The conversation between Person B and the colleague is too distracting, so the team suspends their work and takes a break. Additionally, ignoring the virtual space, Person B wanders through and blocks the view of the scene their team members are looking at. This example illustrates the problems that the users often encounter during the collaboration because of interruptions (Table 1).

## 2.2 Design Considerations

A realistic and straightforward method of dealing with interruptions in XR is to remove the avatar from the virtual environment and disable all forms of tracking. However, this only solves one of the issues (P1). One way to also address P2 and P3 is by replacing the avatar of the absentee with an Absence Agent. The function of this Agent is to enable interaction of the people who stay behind with the absentee and assists the latter to catch up when they return.

For the users that stay behind, the Absence Agent acts as an interface to the actual user. The Agent has access to shared personal information and knowledge of the absentee. It can provide this information to other users. Simultaneously, the Absence Agent receives information on the absentee’s behalf and makes sure it is reasonably delivered to them. It is also imaginable that the Absence Agent could interact with the virtual space on behalf of the user or analyse, compile, and communicate changes in the virtual space back to the absentee as a personal assistant or secretary. An ideal future version of the Absence Agent would use natural language processing and semantic understanding. It could answer questions on the user’s behalf or book and check appointments. However, the presented work does not focus on solving the consequences for the absentee. Catching up may take time because the user might need to take in much information simultaneously.

## 2.3 Implementation

This research aims to create the first version of an Absence Agent. The type of interaction with the Agent and its appearance may be different depending on the type of collaboration. Regarding the appearance, while an Agent that looks similar to the avatar might be easier to identify as a substitute for the absent person and help the feeling of social presence in absence, a less human-like representation might be less obstructing and more inviting to interact with. Additionally, we questioned if the similarity to an avatar might hinder people from interacting with it, as direct interactions might be understood as an intrusion into the personal space of the absentee.

In the scope of this work, we limit the interaction of the Absence Agent to the capability of being moved. Moreover, as the focus of our XR environment lies in verbal communication, we picked recording as the primary interaction with Absence Agents. Users should be able to record audio and video to inform about changes made to the environment or ask questions to the absent user.

We implemented four different Absence Agents along two dimensions (Figure 3) for collaborative XR environments using Unity Engine. The first describes *Appearance* and more specifically, how similar the Absence Agent looks like to the absentee’s avatar. *High Appearance* absence avatars look similar to the avatars embodying the users and *Low Appearance* uses a 2D image resembling a profile

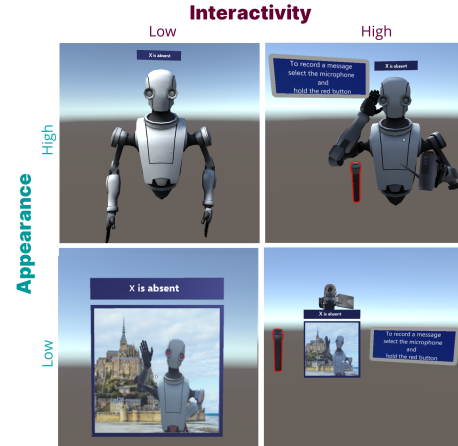


Figure 3: Four variations of absence avatars, classified by the degree of *Appearance* and *Interactivity*.

picture. The other dimension is concerned with *Interactivity*. *High Interactivity* means the other user can move the Absence Agent around and record audio and video for the Absence Agent. *Low Interactivity* Absence Agents do not allow recording messages. The users can only move the Absence Agent around. All Absence Agents have a tooltip indicating that the user is absent. We used the upper part of ‘Space Robot Kyle’ from Unity Asset Store as the avatar.

## 3 CONCLUSION

This paper presents the concept, purpose, and implementation of Absence Agents as a solution to deal with interruptions during collaborative eXtended Reality (XR) tasks. The framework of this study was developed as a collaborative XR environment and it can be used in any general context. A user study in the future could help to evaluate our concept and design of the Absence Agents.

## ACKNOWLEDGMENTS

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