Work-in-Progress: Older Adults' Experiences With an Augmented Reality Communication System

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ABSTRACT

Given the profound impact of staying socially connected on the well-being of older adults, this study explores the potential of augmented reality (AR) systems to enrich their social lives. A wearable AR communication system prototype was developed and tested in a user study involving $N = 16$ older adults from Germany. Participants wore an AR headset and engaged in a conversation task with a remote person represented by an avatar. Older adults' experiences were assessed using think-aloud protocols, qualitative observations, posttest questionnaires, and semi-structured oral interviews. Preliminary findings indicate overall participant satisfaction, with minimal observed difficulties in headset usage and avatar-mediated interpersonal communication. The positive engagement during AR conversations highlights the system's potential to provide positive communication experiences among older individuals. This work-in-progress paper introduces the developed system prototype and outlines the conducted user study. Further data analyses will provide deeper insights into older adults' experiences with the system. The results will contribute to refining the prototype and offer valuable insights for the development of AR communication systems tailored to the needs and preferences of older adults.

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CCS CONCEPTS

• **Human-centered computing** → **Mixed / augmented reality**; *User studies.*

KEYWORDS

Augmented reality, Avatar, Communication, Older adult, Social interactions, User experience

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1 INTRODUCTION

The importance of staying socially connected is increasingly acknowledged for its positive impact on overall well-being. This is particularly crucial for older adults who often face challenges related to isolation and limited social interactions [25]. Age-related factors such as physical and cognitive decline, geographical distance from friends and family, and shrinking social circles can hinder personal visits, making the ability to connect over distances essential for maintaining social relationships [1]. It is therefore not surprising that many older adults are eager and motivated to use modern communication technologies as means of staying in touch with their loved ones [24]. At the same time, they may also feel some reluctance to fully embrace their potential, especially when it comes to innovative technologies [12].

In response to the evolving landscape of communication technologies, augmented reality (AR) systems have emerged as promising tools to bridge geographical gaps and facilitate social connections. Through the use of head-mounted displays (HMDs), AR systems provide users with a simultaneous view of the real-world surroundings and an overlay of digital content [26]. This digital layer often includes life-sized virtual representations of other individuals ("avatars"), enabling users to interact with others remotely through these representations [14]. Attributed to a nuanced transmission of gestures and non-verbal cues, such interactions can result in enhanced emotional involvement with the remote communication partner that resonates with in-person interactions [8, 17]. As a result, AR communication systems hold the potential to create immersive communication experiences, facilitating lifelike virtual visits across geographical distances.

However, despite the growing development of AR systems for communication, these innovations predominantly cater to younger audiences, while their suitability for older adults remain debated [6]. Although some studies argue that AR may present challenges for older adults due to issues like device complexity, sensory impairments, and cognitive decline, others suggest that with appropriate design considerations, AR could offer unique benefits for this demographic [11]. In particular, the immersive nature of AR experiences can be a way to combat social isolation among older adults by facilitating virtual social interactions that enhance the feeling of connectedness [9]. Despite such wide prospects, AR applications for aging population are almost exclusively centered around their physical and cognitive health, while discussions about their possible social benefits remain largely theoretical. This oversight is critical, considering the distinct challenges faced by the aging population in staying socially connected, as well as the rapidly growing number of older technology users [3].

The present study aims to address this gap by evaluating the user experiences of older adults with a prototype of an AR communication system. We developed a prototype of such system and tested it in a laboratory user study with older adults as participants. Our primary goal was to explore whether and in what ways older adults can effectively use this system for communication purposes and how it may enrich their social lives. In this work-in-progress paper, we introduce the prototype of the developed AR system, outline the user study, present preliminary results, and discuss our next steps.

2 BACKGROUND AND RESEARCH QUESTIONS

In the realm of modern technologies, effectiveness, efficiency, and satisfaction are no longer the sole benchmarks; technologies are also expected to provide users with an *experience* [18]. User experience (UX) is defined as a person's perceptions and responses during interactions with a technical device [23]. This holds particular significance for interactive systems like AR, where both good usability and high engagement are essential. For the user group of older adults this becomes particularly crucial, given that their technology acceptance and adoption is often based on perceived ease of use, playfulness, and enjoyment [5, 19].

In the context of interpersonal AR-based communication, perceived social presence is another essential component. Social presence is defined as the sense of being with another person in a mediated environment [22]. A higher degree of social presence fosters social connectedness and shortens the psychological distance between communication partners, ultimately leading to increased communication satisfaction [2]. This aspect is particularly relevant for older adults who face an elevated risk of social isolation and loneliness, often relying on communication technologies to stay connected with friends and family [3]. However, while there is evidence that AR systems can provide vivid communication experiences with high degrees of social presence [14, 26], empirical findings among older technology users are lacking.

Against this backdrop, our study adopts a human-centered approach and focuses on UX of older adults with a prototype of an AR communication system to answer five research questions (RQs):

RQ1: How *successfully* can older adults use an AR communication system with respect to interpersonal communication?

RQ2: How do older adults perceive the *usability* of an AR communication system?

RQ3: How *engaging* do older adults perceive experiences with an AR communication system?

RQ4: How do older adults perceive the *social presence* provided by an AR communication system?

RQ5: How do older adults express their *intention to use* an AR communication system?

3 SYSTEM PROTOTYPE

We developed a prototype of a wearable AR communication system for two users the present study. The system enables the embodiment and visualization of a generic avatar using a Varjo XR-3 headset while providing spatial audio communication between users. The setup involved two communication partners using an application created with Unity 2022.3.8f1. In addition to the HMD, both users wore a Logitech H390 headset for voice communication. Unity's spatial audio was enabled for enhanced audio experiences. The prototype system architecture is illustrated in Figure 1.

The avatar was created with the help of the Character Creator 4 Software Suite 7[1]. The software was used for designing, texturing, and rigging the avatar. Oculus LipSync animated the avatar's lips based on the transmitted audio. Synchronization of users' states and voices over the network was achieved through Photon Fusion and Photon Voice.

The avatar of the remote communication partner was seated at a table facing the study participant. Two HTC VIVE Trackers were used in the room of the study participant to locate the table as well as the chair for the avatar. A virtual plane was added for the table's surface so that the virtual content was occluded correctly as the HMD's depth sensor by itself caused visual artifacts. The avatar was positioned and oriented according to the chair's tracker. The built-in hand and eye tracking of the HMD as well as the head tracking were transmitted and used to animate the avatars in combination with Final IK. In moments where the hands could not be tracked the avatar's hands smoothly moved to a fallback position on the table in front of the avatar.

[1] https://www.reallusion.com/character-creator/ (Last accessed on 13.03.2024)

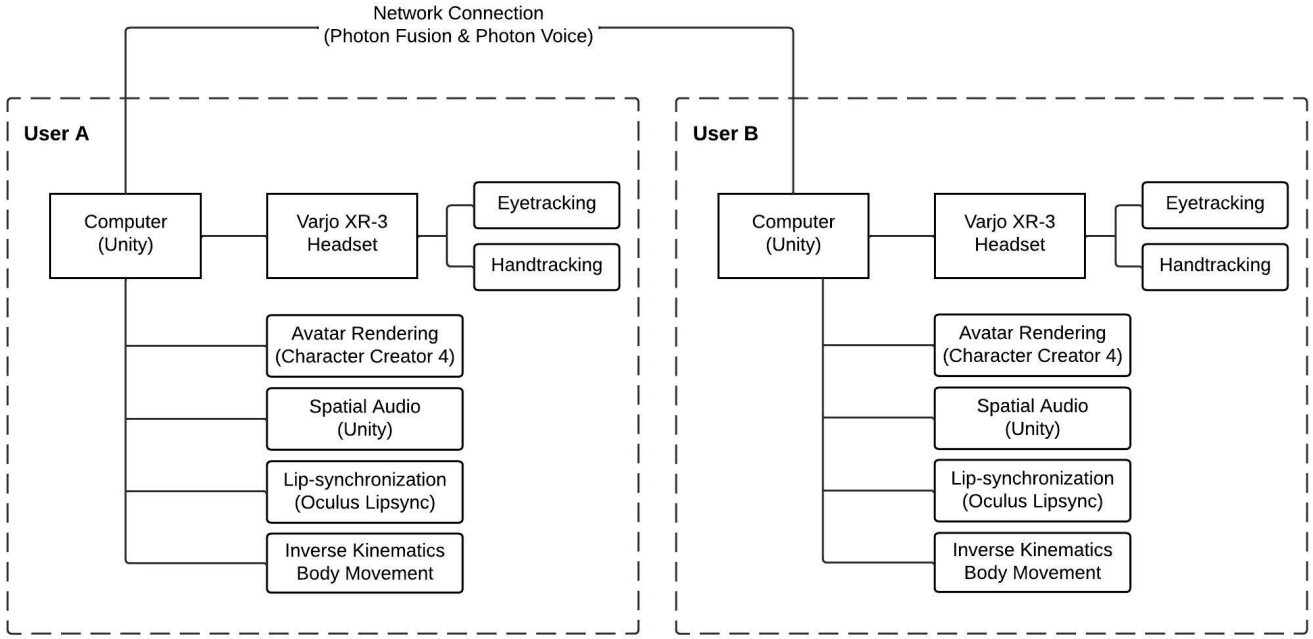

Figure 1: The figure shows an overview of our prototype wearable AR system architecture.

4 USER STUDY

The prototype was evaluated in a user study with older adults as participants. The study had a non-experimental design and combined qualitative (observations, concurrent think-aloud protocols, semi-structured oral interviews) and quantitative (standardized questionnaires and scales) data collection methods.

The study involved participants wearing an AR headset and engaging in a conversational task with a remote and unfamiliar communication partner (a member of the research team) represented by an avatar. The conversation task was a variation of the celebrity guessing game "Who am I?", commonly used in technology evaluation studies [21]. In this game, both the participant and the remote communication partner were provided with a card containing brief information about a famous individual (e.g., name, profession, age). The objective was to guess the celebrity on game partner's card by asking only "yes" or "no" questions. This game was selected as it facilitates social interaction among strangers while maintaining a playful atmosphere. The game's dynamics makes it particularly well-suited for assessing UX and interpersonal communication in AR as it encourages both verbal and non-verbal exchanges between game partners in a lively and engaging setting, even in the absence of prior acquaintance between communication partners [7].

Before the actual data collection, we conducted a pretest with a younger participant to ensure the clarity of the procedure for all participants.

The study is pre-registered: https://osf.io/t82sa. Ethical approval was received from the Ethics Committee of Technische Universität Ilmenau on November 21, 2023.

4.1 Participants

Participants were recruited from prior studies conducted within the CO-HUMANICS (Co-Presence of Humans and Interactive Companions for Seniors) project [13], personal contacts of researchers, and a local sports organization. To meet the eligibility criteria, participants had to be 60 years old or above, express an interest in technology, live independently, and have no cognitive impairments.

A total of N = 16 older adults from Germany participated in the user study (M_{age} = 71.1, SD_{age} = 4.4, 56% women; see Table 1). All participants reported regularly using communication media to connect with their friends and family. Instant messaging services (e.g., Whatsapp, Telegram) were the most common forms of mediated social contacts. None of the participants had any previous experience with interpersonal communication in AR.

4.2 Procedure

The study was conducted in the German language at Technische Universität Ilmenau in February 2024. First, the study goals, procedure, and rules of the celebrity guessing game were explained to the participant, and their informed consent was obtained. Afterwards, the participant filled out a brief entry questionnaire that addressed socio-demographic variables, mediated and non-mediated communication practices, and previous experiences with social AR. Additionally, their general technology acceptance was accessed with a Technology Commitment scale [15].

Following this, the principal investigator managing the user test assisted the participant in putting on the disinfected HMD and headphones. Once the participant indicated feeling comfortable, an avatar representing the remote communication partner appeared in

Table 1: Description of Study Participants

№	Pseudonym	Age	Gender	Education	Mediated contacts frequency[1]	Mediated contacts form
1	Amelie	60	Female	Medium	Several times a day	SMS, instant messaging, video conferencing, social media
2	Lukas	66	Male	High	Several times a week	Instant messaging
3	Sebastian	68	Male	High	Several times a week	SMS, instant messaging
4	Jonas	69	Male	High	Several times a week	SMS, instant messaging, video conferencing
5	Mia	69	Female	High	Several times a week	SMS, instant messaging, video conferencing
6	Emma	69	Female	High	Several times a week	Instant messaging
7	Anna	71	Female	High	Several times a week	SMS, instant messaging, video conferencing, email
8	Finn	71	Male	Low	Weekly	Instant messaging, video conferencing
9	Sophia	72	Female	High	Several times a week	Instant messaging
10	Lara	72	Female	High	Several times a week	SMS, instant messaging
11	Marie	72	Female	High	Several times a week	Instant messaging
12	Hannah	74	Female	High	Several times a week	Instant messaging
13	Leon	74	Male	High	Several times a week	Instant messaging, video conferencing
14	Felix	76	Male	Medium	Daily	SMS, instant messaging, video conferencing, social media
15	Noah	76	Male	High	Weekly	SMS, instant messaging
16	Lena	78	Female	Medium	Several times a day	Instant messaging, social media

[1] – in the past four weeks.

front of the participant, seated on a chair behind the desk. The avatar depicted a White man in his mid-thirties, dressed in sneakers, jeans, and a light-blue semi-formal shirt. All participants were shown the same avatar. The avatar was manipulated by a male member of the research team, who took the role of the remote communication partner from another room. We aimed to maintain consistency by having the same person take the role of the communication partner throughout the study. However, due to availability issues, another colleague had to replace him in several test sessions. The participant and the research team member were not introduced to each other prior to the study, hence the visual resemblance between the avatar and the person behind it was not necessary at this stage. The study participants did not see their own avatars but instead could see their real bodies. Figure 2 illustrates the study setup.

After a brief introduction and small talk, the remote communication partner represented by the avatar invited the study participant to start the celebrity guessing game. The game lasted five minutes. At the end of the designated time, the principal investigator prompted the study participant to ask a final question and say goodbye to the communication partner. During the parting moment, the communication partner offered the participant an avatar-mediated handshake.

Once the avatar disappeared, the principal investigator helped the participant to take off the headphones and the HMD and asked to fill out a posttest questionnaire that assessed their perceived social presence during the mediated conversation with an adapted Social Presence scale [16, 22]. As a last step, the participant took part in a semi-structured individual interview where they were encouraged to share their experiences with the AR system in detail. The open questions that guided the interview covered such aspects as perceived usability of the AR system, as well as different aspects of UX: feelings and emotions during avatar-mediated communication, perceived engagement, and intention to use such system in the future.

After the interview, the participant could ask additional questions and provide feedback.

Every user test was recorded on video, capturing both the room and the participant view. Participants were encouraged to verbalize their thoughts, opinions, or reactions while undergoing the user test, to better understand their experiences. The principal investigator took observation notes throughout the test. Additionally, we recorded tracking data from the HMD (e.g., hand tracking and gaze). Posttest semi-structured oral interviews were audio-recorded.

4.3 Data Analysis Plan

Oral interviews and think-aloud protocols will be transcribed verbatim. Complemented by the observation notes, they will undergo qualitative content analysis using the MAXQDA content analysis software. During the analysis, participants' responses and reactions from the test sessions will be coded into categories and subcategories relevant for answering each RQ. Numeric data from the questionnaires will undergo statistical analysis.

The results will be presented in the form of extracted qualitative categories, verbatim quotes, and descriptive statistics.

5 PRELIMINARY RESULTS AND NEXT STEPS

Currently, the data is being prepared for further analysis. While the qualitative results from the semi-structured interviews and think-aloud protocols are pending, we can already provide preliminary findings based on the observation notes.

Overall, the 16 study participants expressed satisfaction with their AR experiences. Qualitative observations indicated minimal difficulties with wearing the HMD. However, while some complaints were raised regarding the weight and overall comfort of the headset, none of the participants reported any negative physical consequences such as cybersickness or nausea. Notably, wearability concerns are common in user tests with older adults [e.g., 4, 20] and a lightweight headset is a common requirement [13], yet our

Figure 2: The figure illustrates (a) study participants wearing an AR headset; (b) the avatar representing the remote communication partner as seen from the point of view of the participant. The photos are published with explicit written consent of study participants.

participants found the HMD comfortable enough to wear for the study's duration in a seated position.

No discomfort was reported by participants wearing hearing aids, although issues arose with vision glasses. Only one participant managed to wear their own glasses simultaneously with the HMD, while others had to remove them due to size constraints. Despite this, all participants were able to see the avatar well and read the text from the celebrity guessing game cards.

In terms of interpersonal communication, participants remained engaged throughout virtual conversations, displaying visible enjoyment with plenty of smiles and laughter. The handshake at the end of the test session was met with particular excitement:

> "When he tried to shake my hand, did you see it on the camera? Did you see how close that was? Awesome, right? It was really great." (Finn, 71 years old)

Our primary results indicate the generally positive UX observed among study particpants using an AR communication system; however, further analysis of quantitative questionnaires, individual interviews, and think-aloud protocols is necessary for more conclusive insights. Although participants' heightened engagement and interest already highlight the AR system's potential to enhance social interactions among older individuals, special attention should also be given to the perceived degree of social presence experienced by participants during the session. Perceived social presence can influence the degree of connection and trust between communicators and it is a strong predictor of the overall quality and effectiveness of mediated interpersonal communication [10, 22]. Therefore, in our future data analysis, we plan to thoroughly examine this aspect by utilizing both qualitative and quantitative data.

We anticipate that our study results will not only contribute to refining the current AR system prototype but will also help identify challenges, preferences, and opportunities that can guide the future development of similar systems designed to foster social engagement and well-being of older adults.

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