Aware Intelligent Virtual Agent's Effect on Social Presence and Empathy of Caregivers

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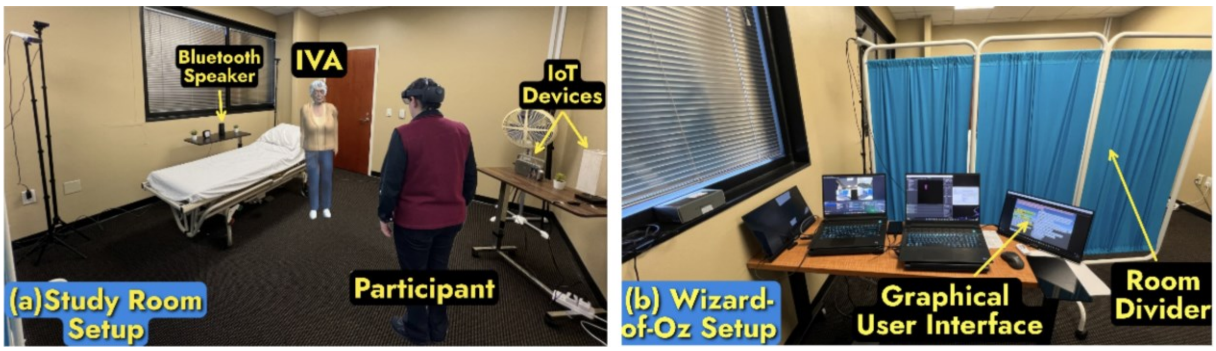

Figure 1: (a) Study room setup for IVA-User interaction session. (b) Wizard-of-Oz setup, hidden from the interaction space.

ABSTRACT

The existing educational programs for caregivers often fall short in providing adequate training for essential interpersonal skills, particularly in communication and relationship development. To address this gap, researchers have highlighted the potential of Intelligent Virtual Agents (IVAs) as a tool for soft skills training across various sectors, including healthcare. In this article, we introduce an aware IVA (A-IVA) designed to represent a geriatric patient, that demonstrates limited and simulated awareness of the environment and previous conversations achieved by Wizard-of-Oz. We developed a novel Augmented Reality (AR) simulation that immerses users in a realistic caregiving scenario. We conducted a pilot study to evaluate how the A-IVA's awareness capabilities influence geriatric caregivers' social presence and empathy levels as compared to an unaware IVA (U-IVA).

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CCSCONCEPTS

• Human-centered computing → Collaborative and social computing systems and tools; Empirical studies in collaborative and social computing; • Applied computing → Computerassisted instruction;

KEYWORDS

Intelligent Virtual Agent, IVA, Virtual Human, Embodied Virtual Human, Embodied IVA, Augmented Reality, AR, Mixed Reality, Social Presence, Empathy, Caregiving, Caregiver, Geriatric Patient, Simulation, Awareness.

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1 INTRODUCTION

The global increase in the aging population has led to a greater demand for geriatric care and caregivers Organization (2024). However, nursing homes face challenges in maintaining adequate staff due to shortages and high turnover rates White et al. (2020). Poor communication skills and insufficient training are significant factors contributing to caregiver attrition Powers and Powers

(2010). To address these issues, various simulation methods, including mannequins and role-playing, are employed in caregiver training nur ([n. d.]); Daher et al. (2018, 2020). Immersive technologies like AR and Virtual Reality (VR) are utilized in healthcare education, with embodied virtual patients serving as platforms for communication skills training Hsieh and Lee (2018). Current research focuses on enhancing caregiving aspects through immersive embodied virtual patients Chaby et al. (2022).

2 RELATEDWORK

Research on embodied IVAs has the potential to enhance humancomputer interactions in various domains, including healthcare and caregiving Bickmore and Cassell (2005); Norouzi et al. (2018). These virtual agents, capable of natural language processing and emotional expression, have been found to increase user engagement and facilitate more natural communication Gratch et al. (2007). Studies have explored the concept of awareness in IVAs, demonstrating that agents with environmental and contextual awareness can provide more personalized and effective interactions Rickel and Johnson (2000). This awareness has been shown to improve the agent's ability to understand and respond appropriately to user needs, potentially leading to enhanced social presence and empathy in human-agent interactions Heerink et al. (2010). IVAs with human-like bodies and social behaviors, including environmental awareness, enhance users' confidence in the IVA's capabilities and increase perceived social presence in augmented reality settings Kim et al. (2019); Kim and Jo (2020). Furthermore, the combination of spatial awareness and embodiment in virtual agents can significantly improve users' sense of both spatial and social presence in simulated environments Schmidt et al. (2020); Daher et al. (2017b,a).

The social presence of IVAs, defined as the sense of being with another, has been a significant focus of research in virtual environments Biocca et al. (2001). Studies have indicated that highly realistic and responsive IVAs can elicit stronger feelings of social presence in users, potentially leading to more effective communication and collaboration Bailenson et al. (2005). In the context of caregiving, research has shown that IVAs with high social presence can provide emotional support and companionship to patients, potentially alleviating feelings of isolation and improving overall well-being Ring et al. (2013). Additionally, the empathic capabilities of IVAs have been explored, with findings suggesting that virtual agents capable of recognizing and responding to human emotions can foster stronger emotional connections with users Paiva et al.
(2017).

The application of IVAs in caregiving contexts has gained increasing attention in recent years Tsiourti et al. (2014). Studies have demonstrated the potential of IVAs to assist in various aspects of care, including medication reminders, health monitoring, and providing companionship to older adults Vardoulakis et al. (2012). Research has also explored the use of IVAs in training caregivers, showing that virtual simulations can effectively improve communication skills and empathy in healthcare professionals Kleinsmith et al. (2015). However, while the potential benefits of IVAs in caregiving are promising, further research is needed to fully understand the long-term effects of human-agent interactions on caregiver empathy and the quality of care provided Bickmore et al. (2010).

To the best of our knowledge, no work has been done on evaluating users' empathy and sense of social presence for geriatric patient care with environmental and conversational aware IVAs in

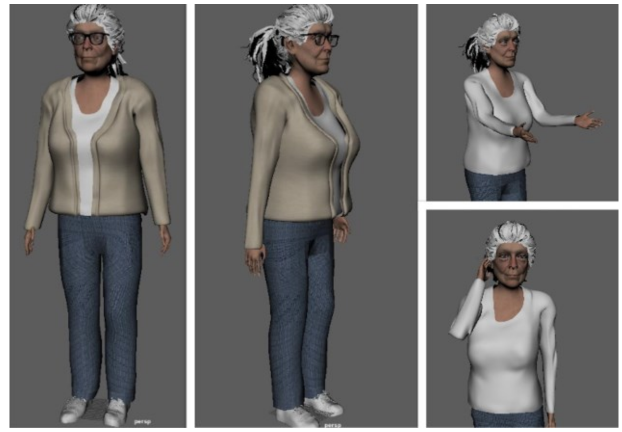

Figure 2: The left and middle columns present two full-view images of the IVA's 3D model from different angles and the right column shows different body gestures.

AR environments. We designed and developed a novel architecture for a geriatric IVA that gives users the impression that the IVA is aware of its environment and previous conversations, addressing a gap in existing research Ahmmed et al. (2024). To address the gap, we conducted a pilot study to evaluate how this A-IVA affects caregivers' sense of social presence and empathy towards older patients.

3 SIMULATIONDEVELOPMENT

The design and development of our simulation encompass four primary components: (1) a 3D model representing the IVA, (2) management of IVA responses, (3) enabling emotional expressions and movements, and (4) IVA awareness. The system was developed in Unity 3D using C# that utilizes an AR interface, displayed through a HoloLens 2 head-mounted display, presenting a three-dimensional representation of an older woman as the IVA. Our IVA is capable of engaging in organic dialogues, exhibiting various emotional states and physical movements, and demonstrating limited awareness of its environment and conversations. The IVA's responses and its awareness feature are managed through a Wizard-of-Oz approach, where a human operator selects appropriate responses from a preestablished set and manipulates Internet of Things (IoT) devices from the background.

The 3D IVA model was created using the Maya modeling software, focusing on realistic design with detailed animations and facial expressions. The model comprises 778,092 vertices, 1,496,271 edges, and 719,428 faces, with textures created in Adobe Photoshop and mapped to UV layouts. The rigging includes 67 joints for a wide range of motion, with special attention given to facial rigging for accurate speech articulation and emotional expression. Lip synchronization, emotions, and gestures are managed through a custom-made plugin utilizing the SALSA LipSync package within Unity. Our plugin automatically configures settings in the SALSA and emoteR components, initiating facial expressions and emotions in synchronization with corresponding audio clips (IVA speeches).

The IVA's responses are controlled through a Graphical User Interface featuring categorized button panels. These buttons activate speech, facial expressions, and body animations. A button manager parses data from an Excel file to create and organize the buttons. The system includes a semi-automated database management system within Unity to store information about responses, facial expressions, and body gestures. Real-time data transmission between the IVA and the human controller (GUI) is facilitated through a two-way communication system using TCP and socket programming.

The awareness feature of the IVA is incorporated through two methods: environmental awareness (controlling IoT devices, recognizing clothing colors) and conversational awareness (recalling information from past interactions, i.e., identifying users by their names). The awareness features were achieved through preprogrammed information and simulated control of devices by the human operator. The system's design allows for authentic and responsive interactions between users and the IVA, creating a realistic and immersive experience in geriatric care simulation.

4 PILOTSTUDY

This user study was approved by the Institutional Review Boards at the New Jersey Institute of Technology and the University of Central Florida(UCF). We employed a within-subject methodology to evaluate users' interactions with an IVA simulation. The study was conducted in the College of Nursing, at UCF. Participants included 16 individuals with nursing backgrounds, predominantly female (15 out of 16), aged 18-25 years. The group was ethnically diverse and primarily comprised of USA-born and raised individuals. Professionally, they ranged from Certified Nursing Assistants to nursing students, all with prior experience in geriatric care. About half of the participants had previous exposure to immersive technologies.

The study setup mimicked a geriatric care facility, featuring a bed, tables with various items, and remotely controlled IoT devices (a lamp and a radio). The IVA was projected holographically near the bed, with participants instructed to interact in close proximity. A room partition created a semi-private interaction area and concealed the human operator's setup. The study involved two scenarios designed to demonstrate the IVA's awareness of its environment and ability to recall previous information. Participants interacted first with an unaware IVA (U-IVA), followed by an aware IVA (A-IVA). In the first scenario, participants introduced themselves to the U-IVA and engaged in conversation. The purpose of this interaction is to allow the participants to introduce themselves to the U-IVA, and the IVA did not actively exhibit awareness at this stage. In the second scenario, participants interacted with the A-IVA, which demonstrated awareness by recognizing participants by name from the first interaction, identifying and commenting the color of participants' outfits, and manipulating IoT devices. Participants completed tasks such as motivating the IVA to participate in activities (first scenario) and informing it about a family visit (second scenario). The duration of interactions varied and was at the discretion of the participants. Conversations were not dictated by the human controller and flowed naturally.

Measurements were taken using questionnaires before and after the interactions. We assessed empathy using Jefferson's empathy instrument (20 questions on a 7-point Likert scale) Shariat and Habibi (2013) before the first and after the second scenario. We measured the participants' sense of social presence using a 36-question instrument across six dimensions (Co-Presence, Attention, Perceived Message Understanding, Perceived Affective Understanding, Perceived Emotional Interdependence, and Perceived Behavioral Interdependence) on a 6-point Likert scale Biocca et al. (2001) after the first and second scenarios. This within-participant study design allowed for a detailed examination of how participants' perceptions of empathy and social presence were affected by interactions with the IVAs (U-IVA and A-IVA) demonstrating different levels of awareness in a simulated geriatric care environment.

5 PRELIMINARYRESULTS

The study results reveal an increase in participants' empathy and sense of social presence scores following their interactions with the U-IVA and A-IVA. The findings were more varied across the six dimensions of Social Presence (i.e., co-presence, attention, perceived message understanding, perceived affective understanding, perceived affective interdependence, and perceived behavioral interdependence). Social Presence dimensions of attention, perceived affective understanding, perceived emotional interdependence, and perceived behavioral interdependence, showed increased scores in the post-test evaluation as compared to the pre-test evaluation.

6 LIMITATIONSANDDISCUSSION

The pilot study had a small sample size. Participants had an imbalanced gender distribution (one male and fifteen females) as it is expected in the nursing population. The simulation supported a limited set of pre-recorded IVA responses. Additionally, by design, the study had non-counterbalanced conditions given that the scenario setting is healthcare-related. We maintained a fixed U-IVA/A-IVA sequence (i.e., non-randomized order) to prevent potential negative training effects or misconceptions among the nursing participants, such as mistakenly assuming participants were interacting with a dementia patient in the case of A-IVA followed by U-IVA.

7 FUTUREDIRECTIONS

Our future development plans include integrating Large Language Models (LLMs) to automate the IVA's responses, thereby replacing the current Wizard-of-Oz approach. The integration of LLMs will expand the range and flexibility of the IVA's conversational capabilities, addressing the current limitation of relying on a relatively confined set of pre-recorded responses. Moreover, the implementation of LLMs has the potential to enhance the system's cost-effectiveness by eliminating the need for human operators.

This transition could also improve the overall ease of use of the system, making it more accessible and adaptable for various applications and settings.

8 CONCLUSION

We introduced a novel architecture of an Intelligent Virtual Agents demonstrating simulated awareness of their environment and previous conversations. We conducted a pilot study in a geriatric setting to evaluate the impact of the system on users' empathy and sense of social presence. Participants from the nursing and caregivers community had two sessions to interact with an unaware IVA (U-IVA) and an aware IVA (A-IVA). They filled out pre- and post-test surveys before and after interacting with the IVAs. Preliminary findings show an improvement in both empathy and social presence scores when comparing the pre- and post-interactions with the IVA with simulated awareness.

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