Simulation of an Aware Geriatric Virtual Human in Mixed Reality

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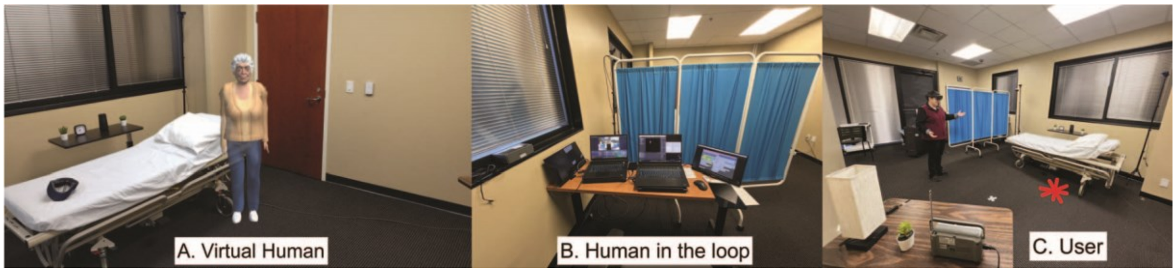

Figure 1: Demo setup- A) 3D virtual geriatric human. B) Human-in-the-loop setup: the human controller operates behind the blue screen. C) A user interacting with the virtual human. The red asterisk mark represents the location of the virtual human.

ABSTRACT

We present an Augmented Reality (AR) experience, enabling user interaction with a Virtual Human (VH) of an older adult. We demonstrate the feasibility of the technology to foster communication and social connection between caregivers (users) and older adults (the VH). We developed a 3D model of an embodied virtual geriatric patient that demonstrates awareness of its environment and conversations, and implemented a networking protocol for remote response control with a human in the loop.

Index Terms: Human Centered Computing—Human Computer Interaction—Augmented/Mixed Reality—Virtual Human—Older Adults—Geriatric Patient Care—Simulation

1 MOTIVATION

The US population aged 65 and older has seen a significant increase of 34.2% in the last decade, with a predicted rise to 23.4% by 2034 [1]. Despite the growing number of unpaid caregivers, the high turnover rate and a persistent shortage indicates an escalating demand for caregivers [4]. One potential factor behind the elevated turnover rate is insufficient training [4].

Augmented and Virtual Reality are used in healthcare simulation to improve training. Specifically, Virtual Humans (VH) can be used to improve soft skills such as communication [2]. Creating rapport with Geriatric patients is an essential skill for caregivers; this requires continuity of conversations. The impact of a VH's awareness of its environment on user engagement has been studied [3]. Our VH demonstrates the importance and feasibility of the VH being aware of the conversations and surroundings in simulation, especially in geriatric applications.

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2 APPLICATIONS

Recent breakthroughs in immersive technologies, such as AR and VR, have broadened the scope of potential applications, particularly in sectors like healthcare, education, training, entertainment, and gaming [5]. We developed an AR-based application that simulates a geriatric patient as an interactive conversational embodied VH. The user (e.g., caregiver) conducts one or more conversation with the VH. The VH demonstrates awareness of the environment and conversation.

We interviewed 10 professional caregivers before we developed content for training. The training scenario allows caregivers to practice soft skills via multiple interactions, and to provide an exposure about what to expect when caring for an older adult as a preparation prior to caregivers joining the professional field.

This technology is generalizable to apply to other fields such as healthcare in general or any application where an interaction with a human (or VH) is needed. For example, healthcare providers using VH to simulate a patient, or as an assistant.

3 NOVELTY

We used the Microsoft HoloLens 2 mixed reality headset to display the VH. The VH can express emotions, exhibit body gestures, respond to users' inquiries, and shows awareness of its environment and conversation. The VH's responses are managed

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by a human controller in real-time to ensures swift and coherent replies (See Figure-2).

3.1 3D Model of a Geriatric VH

We created a 3D model for an old woman using Autodesk Maya using 3D Scans from 3dsk, and Turbosquid as references. The model closely mirrored the intricacies of real human anatomy and skin texture. The realism extended from the subtle sagging of the skin
to the fine lines that characterize elderly facial features. The model is designed to be anatomically accurate while reflecting real-life characteristics of an aging individual and is compatible for interactive real time applications such as Virtual and Augmented Reality. Throughout the modeling process, we created textures of 2048 pixels x 2048 pixels resolution to replicate the unique properties of elderly skin and tone variations. The 3D mesh has 778,092 vertices, 1,496,271 edges, 719,428 faces. The mesh was rigged with a skeleton that contains 67 Joints to allow for body animations including

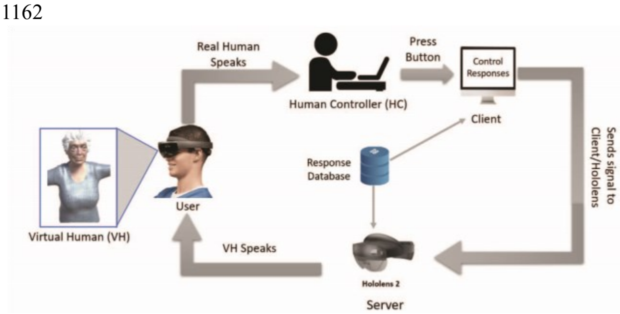

Figure 2: User interaction workflow diagram: the diagram shows the behind the scene process of the VH responding to the user.

fine movement such as fingers and jaw. We also rigged the mesh with blend shapes for facial animations, which included visemes corresponding to sounds like 'p-m-b', 'f-v', 't-d', 'k-g', 'ch', 'a', 's', 'n', 'l', 'r', 'e-ih', 'o', and 'th'. These were complemented by facial expressions capturing emotions such as happiness, anger, sadness, surprise, and nuanced actions like brow raising and blinking. The body animations we developed include everyday actions like waving, sitting, and pointing. The model files were exported as FBX then imported into unity.

3.2 VH Response Control

We employed a Human-in-the-loop approach to manage the response generation of the VH. The VH response control system consists of the Graphical User Interface (GUI), the response control database, and the response data transmission mechanism.

3.2.1 Graphical User Interface

A human controller listens to the users' speech in real-time, and responds from the GUI of pre-created responses in Unity3D. Each response is stored in a database and shows as a button in the GUI. Upon pressing a button, the corresponding audio response and animation is relayed back to the user through the VH via the Hololens 2. We created a custom built Unity plugin to enables the concurrent operation of audio playback, lip synchronization, facial expressions, and body gestures of the VH. 3.2.2 Response Control Database

We have implemented a semi-automated database system for controlling the responses of the VH. This system maintains a spreadsheet that houses the responses (e.g., button name, the full text of the corresponding response, and the name of the associated audio file). We read this information from the spreadsheet and construct a user interface within Unity. To add new responses, or buttons, into the GUI, one simply needs to edit the spreadsheet.

3.2.3 Data Transmission

Upon the user posing a question to the VH, the human controller selects a response and activates the corresponding button, thereby transmitting a signal to the HoloLens. This process is facilitated by a real-time, bidirectional TCP server-client communication implemented via socket programming in Unity. In this network, the Hololens 2 functions as the server, while the button interface serves as the client. Prior to the user interaction session, a connection is established between the server and client, ensuring uninterrupted communication throughout the user-VH dialogue.

3.3 Unity Plugin: Lipsync and Facial Expression Controller

We developed a Unity plugin that dynamically activates lip synchronization and facial expressions on the VH during user interactions.

We utilized the SALSA Lipsync Suite Pro (v2) module, which facilitates the generation of mouth movement visemes and emotions using blendshapes. The plugin extracts information from the response control database and incorporates it into the VH. Upon receipt of a signal from the GUI, our plugin activates the corresponding mouth movements and facial expressions in conjunction with the audio clip for the response chosen by the human controller.

3.4 VH Awarenes

We incorporated an awareness attribute into the framework, enabling the VH to exhibit awareness of its surroundings. This includes remembering something personal about the user such as their name or recognizing the color of users' attire. Users' names and dress colors are preemptively entered into the database and linked to a response button in the GUI for subsequent use during a session. In addition, the VH exhibits control over IoT devices such as a lamp or radio. The controller employs a remote control to manipulate the IoT devices, turning the lamp and radio on or off as needed.

4 Research Directions

We conducted a pilot study involving 20 professional caregivers including professors, students, and working caregivers. Each participant had an interaction with the VH under predefined scenarios. We received positive feedback for the system regarding the user friendliness, interactivity, and realistic representation of the VH while suggestions for enhancing the system included adding mobility features to the VH and a broader range of responses. The longest conversation that the VH maintained was just under 16 minutes.

Our future developments will focus on creating content for training caregivers in challenging situations. Furthermore, we plan to incorporate Artificial Intelligence (AI) such as generative AI to manage the responses of the VH.

5 Conclusion

In this research, we introduced a novel immersive AR simulator framework featuring an embodied virtual geriatric patient. Our custom VH is capable of verbal and non-verbal communication during user interactions, and capable of demonstrating awareness of the environment and conversation. We tested the feasibility of the technology with professional caregivers.

Acknowledgments

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