

Research Statement

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Human to virtual human interaction may be regarded as the next frontier in interface design, particularly for tasks that are social or collaborative in nature. Virtual human interfaces or embodied conversational agents, while challenging to develop and evaluate, have the potential to revolutionize the accessibility, usability, and applicability of computers in everyday life. Research evidence suggests that people can accomplish tasks more effectively when the behavior and attitude of an interface agent is similar to a real human. Since virtual humans are modeled after humans, these interface agents can use several modalities for communicating information, such as gestures, facial expressions, which are transparent or obvious to the user. Research in the area of Virtual Human Interfaces is scattered among a variety of fields, including agent systems, animated characters, user emotions, graphics and animation, user and cognitive modeling, conversational interface agents, animated pedagogical agents, virtual reality, and human factors.

My primary area of research lies in understanding the impact of social function on human-virtual human interaction. Specifically, the goal of my work is to investigate what social or conversational tasks are best suited for a virtual human interface agent, and how do these capabilities affect social factors such as engagement, satisfaction, acceptance of the interface agent's role, and the success of task performance in an interactive social or public setting. To this end, I have created a virtual human interface agent framework for the purpose of studying human-virtual human interaction. Using this framework, I studied the impact of an agent's social conversational capabilities on users' perceptions and treatment of a virtual human interface agent in a deployed public setting. I also showed that users can be trained in verbal and non-verbal social conversational protocols/conventions using natural multi-modal interaction by virtual human interface agents.

Virtual Human Interface Framework as a platform for Studying Human-Virtual Human Interaction:

In the past there have been several embodied conversational agents created for specific pedagogical, training, and collaborative applications. Research evidence suggests that social factors such as voice, appearance, behavior, and personality of a virtual human interface agent may have particular importance in social or collaborative tasks. Research evidence also suggests that decisions regarding what social factors are necessary in effective human-virtual human interaction (such as appearance and personality) are frequently based on introspection rather than careful consideration of the tasks and the users of these systems. There is a need for a platform to evaluate the impact of these social factors in deployed autonomous embodied agents in task oriented encounters. In particular, an extensible application framework that supports all of these aspects of a virtual human interface agent is needed.

To this end, I built the Virtual Human Interface Framework (VHIF), and created Marve, a virtual receptionist, as a proof-of-concept application built using VHIF. VHIF incorporates the existing relevant technologies to create real-time autonomous embodied conversational interface agent systems. VHIF facilitates the systematic study of both the tasks for which virtual human interfaces are particularly suited, and the aspects of these interfaces that are most important to the effective accomplishment of these tasks. VHIF is an extensible and modular framework that combines speech, graphics, voice recognition, cognitive and user modeling capability, and a real-time planner. Marve was deployed next to the primary entrance of the Future Computing Lab and had the ability to interact with visitors and lab members to take and deliver messages, and

provide reminders of important events and responsibilities. Even with his limited capabilities, I noticed that people treated Marve as a social entity and it inspired me to study how additional social conversational capabilities might influence users' interactions with Marve.

Evaluation of Social Conversations with a Virtual Receptionist:

In further studies I explored the impact of social conversation in human-virtual human interface interaction. In order to ascertain the underlying theoretical basis of the impact of social conversation in human-virtual human interaction, I conducted user studies to determine if users will engage the interface agent in social conversations and how users perceive and treat such an interface. Research in inter-personal communication suggests that social conversation helps people establish and maintain social relationships and accomplish tasks. People commonly use social dialogue such as small talk to help ease the way into conversation, help establish common ground, and build solidarity or trust. Marve's conversational capabilities featured a subset of context independent social conversation such as an entertaining task (telling knock-knock jokes), small talk (talking about current movies), and a social informative task (discussions on the current weather) apart from his role-specific goal oriented task of message taking and delivery.

The results suggest that the virtual human interface agent was able to engage users in social conversations in informative, entertaining or context independent human-like social dialogue a significant amount of the time. A significant majority of users enjoyed social conversations with Marve, and perceived Marve as a human-like conversation partner. Anecdotal evidence also suggests that users tended to respond and treat Marve as a social entity. My findings also suggest that people will use virtual human interfaces and are comfortable using inter-personal social communication protocols with them, such as greetings, goodbyes, small talk elements, and obtaining information through dialogue. These findings then led me to study whether virtual humans can teach and train human users in social conversational verbal and non-verbal protocols. The specific research question being, if human users perceive and treat virtual human interfaces as social conversational partners, can virtual humans teach users social conversational conventions?

Using Immersive Virtual Humans to Teach Social Conversational Protocols:

Virtual humans have the potential to engage and train human users in tasks that involve interpersonal verbal and non-verbal conversational behaviors in face-to-face social contact. Virtual human pedagogical agents have been shown to be effective in training users in collaborative tasks such as patient interview training in triage, virtual tutoring, and mission rehearsal exercises. I explored the use of immersive virtual humans to train users in social conversational verbal and non-verbal behaviors pertaining to conversational initiation and disengagement in south Indian culture. Social conversational protocols in south Indian culture are highly structured and specific to the gender, age, and status of the interlocutor. The temporality, intensity, and synchronicity of the verbal greetings, non-verbal gestures, and eye gaze are well-defined by the rules of etiquette for conversational initiation and disengagement.

In order to test the effectiveness of using virtual humans to teach social conversational protocols, I conducted a study where I compared natural multi-modal interaction with immersive virtual humans to reading a written study guide with illustrations of the social protocols. My hypothesis: Natural multi-modal interaction with immersive virtual humans can successfully train naïve users in south Indian social protocols.

Results of the study suggest that participants who trained with and gained interactive natural multi-modal feedback from the immersive virtual humans performed significantly better than participants who learned from a written study guide. The results also revealed that there was no significant difference in positive or negative affect between conditions.

Future Directions:

Building upon the foundations of my doctoral research, my future plans include the following. 1. Discovering the impact of social factors in human-virtual human interaction in deployed real-world settings. 2. Investigating the impact of multi-modal interaction, immersion, and realism of virtual human interface agents as pedagogical social agents. 3. Identifying key social collaborative task-oriented application areas best suited for virtual human interface agent frameworks.

Social factors such as appearance, multi-modal response, personality, and social conversational repertoires can have a major impact on user's perception and usability of virtual human interfaces in public real-world settings. One of the limitations of previous studies has been that virtual human interfaces have been evaluated in constrained scenarios such as research labs, where the majority of users were a technologically savvy sample of computer scientists. Using my Virtual Human Interface Framework, I plan to investigate the impact of virtual human interface agents on a more diverse audience by deploying such interfaces in social real-world settings. I also plan to investigate factors, in addition to social conversation, that might enhance trust, engagement, and successfully support the development of social relationships between virtual human interface agents and people in a social real-world setting.

Understanding the effects of immersion, natural multi-modal interactive feedback, realism, and human-like behavior on cognition will facilitate the creation of effective pedagogical embodied conversational agents. Virtual human interface agents have profound implications in teaching and training users in a multitude of social collaborative skills such as interviewing, counseling, and tutoring. Using my Immersive Virtual Human Social Conversational Training System as an evaluation platform, I would like to compare learning social conversational etiquette with immersive virtual humans to learning from video-based instruction. I would also like to vary the use of natural multimodal feedback as part of the instruction to study its impact on cognition. In further studies, I would also like to evaluate the effect of learning social conversational conventions as part of a narrative scenario with social consequences as opposed to standardized instruction.

Models for inter-personal dialogue and discourse from social psychology research can contribute positively to enhance human-virtual human interaction. Psychology research suggests several enhancements, such as a strategy of using self-disclosures from time to time, or laughing at a user's jokes, may increase users' perceptions of friendliness, attraction, and competence, which may result in greater satisfaction and engagement with the virtual human interface. In future studies I would like to investigate the use of social psychology inspired models in virtual human interface agents like Marve, and its impact on factors such as task performance, satisfaction, and edutainment. Furthermore, I would like to discover what additional factors result in positive and negative outcomes of using such models as part of the virtual human metaphor.

Collaborative Research: I am also interested in several collaborative research ventures. I am interested in robust, cost effective *computer vision* applications for user input and motion tracking of gestures and facial expressions to facilitate natural multi-modal interaction with virtual human interface agents in public settings. I am also interested in integrating AI techniques from *data mining* and *machine learning* fields to create accurate user models of interest and emotion, and to develop effective methods for cognitive modeling and planning of conversational events in virtual human interface agents in mixed-initiative interactions. My research interests also lie in employing the latest *natural language processing* techniques in real-time context independent speech input to enhance communication with virtual human interface agents.

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