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Designing Artificial Intelligence (AI) in Virtual Humans for Simulation-Based Training with Graduate Teaching Assistants

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Abstract: In this case study, we explored the design and usability of an AI virtual human design architecture. Data from 50 hours of project meetings and 35 hours of user-testing and prototyping sessions contributed to the preliminary results. The study findings indicated the potential of using AI-integrated virtual humans to support conversational and interactive training for student instructors in an open-source virtual reality environment. Moreover, the AI student prototyped was found to be authentic and semantically meaningful.

Introduction and theoretical background

Teaching is complex problem solving. Prior research demonstrated that authentic simulation-based learning can facilitate knowledge application and skills practice for learning to teach (Chernikova et al., 2020). However, designing virtual humans with artificial intelligence (AI) to convey naturalistic interactions with student instructors in virtual reality is still a challenge. Furthermore, empirical research is lacking on how to design AI virtual humans using an interdisciplinary and systematic approach.

According to Hayes-Roth and Thorndyke (1985), AI typically manipulates multiplex architectures to represent ill-structured problem-solving solutions. To represent the AI architectures for educational purposes, understanding human behaviors and modeling human cognition and character traits are integral parts of virtual human design (Johnson & Lester, 2018). To this end, Nye et al. (2014) used semantic analysis with a discourse framework to create natural language dialogues to promote learners' (i.e., graduate teaching assistants in our study) knowledge application and problem-solving skills development. Essentially, *expectations-misconception* mechanism was used to tailor natural language dialogues that model student knowledge and individual differences so that the virtual students can be designed to stimulate preservice teachers' practice with the targeted activities (e.g., Nye et al., 2014; Paladines & Ramírez, 2020). However, it remains a challenge to design such natural-language-enactive virtual humans in 3D virtual environments that utilize low-level implementation programming languages such as Linden Scripting Language (LSL) (Ke et al., 2020). Nevertheless, an open-source, multiuser virtual reality (VR) platform like *OpenSimulator (OpenSim)* is usually more customizable and accessible and hence are more likely to be scalable and equitable for a larger population. The current study is an ongoing exploration of designing AI in the virtual world. The following question is explored: *How does an AI-integrated virtual human design architecture and process come about in a VR simulation-based learning environment?*

Method

As part of an ongoing design-based research project on simulation-based training of student instructors, we documented three iterative cycles of virtual humans (or virtual students, in this study) design in a simulation-based environment in *OpenSim*. We employed a case study approach to investigate the design experience and artifacts in situ. Each iterated design cycle, including its design activities and artifacts, works as a design case that is bounded in a twenty-five-week design period. Interactions and behavioral data elicited in the iterative design process was collected from a total of 50 hours of project meetings, 22 hours of paper prototyping sessions, and 13 hours of functional virtual human prototyping. The paper prototype was made via Microsoft excel sheet with comprehensive syntaxes whereas functional prototypes were created first with RPG Maker MV and then in *OpenSim*. We triangulated the data collected from meeting notes, design documents, design artifacts, screen recordings, and semi-structured interviews with the in-field test users. In the following sections, we present the preliminary results from the open coding analysis of the current case study.

Results

Process and architecture of the AI virtual human design

To develope dynamic, conversational, and interactive AI-integrated virtual humans (see Figure 1, left), we developed an architecture that utilizes both high- and low- level programing languages and external knowledge database with text mining techniques (see Figure 1, right). For agent modeling, we first reviewed the literature on

learning and individual differences to outline salient traits and characteristics of virtual humans. Next, we finalized seven individual differences with either a three-point or two-point scale for the machine to interpret as the default characteristics of the virtual students. For example, motivation (0=low; 1=medium; 2=high) or cognitive fixedness (0=no; 1=yes). These characteristics result in four main categories of virtual student states: affective, cognitive, metacognitive, and behavioral. These states are dynamic and changeable from the interactions with the graduate teaching assistants and the teaching contexts (i.e., global rules). The states transition is engineered with external knowledge database and the communications between high-level programming languages and LSL.

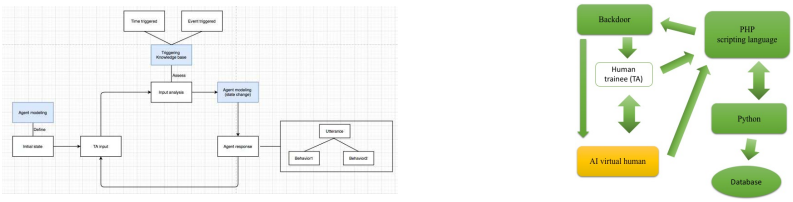

Figure 1. The virtual humans architecture designed for virtual reality using *OpenSim*.

Virtual humans' usability

The preliminary results with front-end users (i.e., expert instructors and designers) and college students (i.e., the population of the agent being modeled) suggest that the design of the virtual students is authentic and semantically meaningful. All participants provided positive feedback. For example, being asked if the virtual students design prototype is naturalistic, Mateo (pseudonym) responded, "*Yeah, I can see that happening.*" The design of challenging teaching situations also reflected what college students experienced in daily life: "*I know there was one student that was annoying that I've come across in all the classes I've taken so far…she would asked questions that…don't really applied to what he* (re: the professor) *was teaching*" (Mateo). Moreover, Shelly (pseudonym) revealed the important role of psychology and agent modeling in the AI virtual human design: "*it's good to know how people work when you're teaching them."* For disruptive student agent behavior design, Shelly commented: "*some students are very extroverted and they're very vocal about how they feel…(their complaints) makes me uncomfortable, like the conflict between a teacher and student.*" These comments suggest that the current virtual student agents were associated with a balanced design between the behavioral and affective states as well as the cognitive and metacognitive states.

Conclusion and Implications

This current study demonstrates the potential of designing and using intelligent virtual humans in a virtual environment (Ke et al., 2020). Specifically, the proposed design architecture consists of state-of-the-art mechanisms and has the potential to tailor natural language dialogues (Nye et al., 2014; Paladines & Ramírez, 2020) between the graduate teaching assistants and virtual students in a 3D virtual world based teaching simulation. Current user-testing data indicate that the designed virtual students are perceived as authentic and semantically-meaningful. This design-based research should foster conversations between and reflections of interested stakeholders in virtual human design and development for teaching and learning in a virtual world.

References

Chernikova, O., Heitzmann, N., Stadler, M., Holzberger, D., Seidel, T., & Fischer, F. (2020). Simulation-based learning in higher education: A meta-analysis. *Review of Educational Research, 90*(4), 499-541.

Hayes-Roth, B., & Thorndyke, P. W. (1985). Paradigms for intelligent systems. *Educational Psychologist, 20*(4), 231-241.

Johnson, W. L., & Lester, J. C. (2018). Pedagogical agents: back to the future. *AI Magazine, 39*(2).

Ke, F., Dai, Z., Dai, C-P., Pachman, M., Chaulagain, R., & Yuan, X. (2020). Designing Virtual Agents for simulation-based learning in Virtual Reality. In R. Zheng (Ed.), *Cognitive and Affective Perspectives on Immersive Technology in Education* (pp. 151-170). Hershey, PA: IGI Global

Nye, B. D., Graesser, A. C., & Hu, X. (2014). AutoTutor and family: A review of 17 years of natural language tutoring. *International Journal of Artificial Intelligence in Education, 24*(4), 427-469.

Paladines, J., & Ramírez, J. (2020). A Systematic Literature Review of Intelligent Tutoring Systems with Dialogue in Natural Language. *IEEE Access*, *8*, 164246-164267.

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