Mixed-Reality Humans for Team Training

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Team training is increasingly necessary for safe, effective healthcare.[1] Many patient care errors have been due to clinicians' inability to function as an effective team.[2] Commonly reported errors have been linked to communication failures, poor coordination, and fragmented care.[3] These problems result in medication errors, death, and many other patient safety issues.[4]

Medical and health professions schools often use simulations to prepare students to work on interdisciplinary teams.[5] However, beyond a formal educational context, bringing team members together for training in busy healthcare systems is extremely difficult.[6] For example, intraoperative-cardiac-arrest practice requires an anesthesiologist, a midlevel anesthesia provider (a nurse anesthesiologist, an anesthesia assistant, or an anesthesiology resident), a surgeon, a midlevel surgical provider (a surgical resident or physician assistant), two nurses, and a surgical technician. These people are rarely all available for training at the same time at a suitable location.

Without all the team members, training—if or when it happens—becomes fragmented. The result of limited, inconsistent, and unreliable team training is that implementing best-practice protocols is much more difficult. This causes the persistence of suboptimal outcomes that affect patient safety, despite knowledge of effective solutions.

To address these issues, we propose *mixed-reality humans* (MRHs)—virtual humans that inhabit the users' physical space (see Figure 1). MRHs combine the dynamic visuals of virtual humans with the physicality of mannequin patient simulators.[7] This hybrid configuration enables them to assume the roles of unavailable human team members, essentially allowing on-demand team training.

Animatronic Digital Animated Avatars

In 2010, we began work on ANDI (*An*imatronic *D*igital Animated Avatar), a proof-of-concept MRH for multiparty interaction. ANDI is an initial investigation into

- a mobile platform that can be integrated into a training environment and
- a simulator that supports interaction between a human and two virtual humans.

ANDI comprises

- a laptop for computation, networking, and rendering;
- a 40″ LED-backlit LCD TV (<75 W power consumption) and a TV stand;
- a 600-W uninterrupted power supply;
- a Microsoft Kinect for tracking the user's head for perspectively correct rendering;
- a wireless microphone for speech capture; and
- a stepper motor with an Arduino Uno microcontroller to control the physical props.

The components cost approximately US$2,700, significantly less than many clinical training systems.

ANDI's head, torso, and arms are virtual, rendered on the TV using a virtual-human model from Autodesk's Evolver. ANDI's legs consist of actual scrub pants (filled with stuffing) and shoes, which rotate in synchrony with the virtual components. The physical props serve to integrate ANDI into the user's space.

We applied ANDI to two simulation scenarios. The first involved myocardial ischemia, a common complication of intermediate and high-risk surgeries that involves insufficient oxygen supply to the

Published by the IEEE Computer Society

heart. In this scenario (see Figure 1), three medical professionals worked together to evaluate and treat the patient. The participant played the role of the anesthesiologist or the post-anesthesia care unit nurse. ANDIs portrayed the second team member (the post-anesthesia care unit nurse or the anesthesiologist) and the surgeon.

The second scenario involved scoliosis repair, which deals with the spine. We based it on a real case in which significant confrontation occurred among team members. In this scenario (see Figure 2), the participant played the role of an operating room (OR) nurse. ANDIs portrayed the patient's mother, an anesthesiologist, and an aggressive surgeon who insisted on violating procedural policy, even though that action might have endangered the patient.

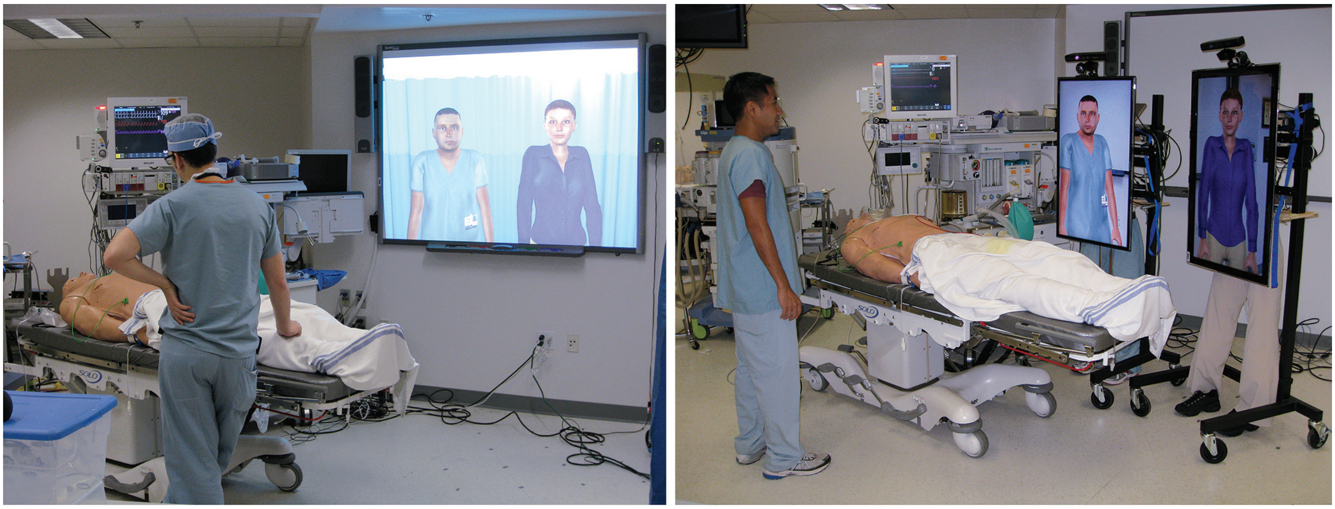
Using these scenarios, we conducted multiparty-interaction studies with medical students and professionals. In these studies, ANDI demonstrated four important capabilities. First, it presented a virtual human that physically occupied and moved in the environment. Second, it was self-contained and portable. Third, it presented social conversation cues. Finally, it successfully interacted with a human and another ANDI.

Figure 1. In a clinical training environment, a trainee works on a team with a mixed-reality human (MRH) that role-plays a team member. The MRH combines virtual components (for high-dynamics areas such as the head and arms) and physical components (for low-dynamics areas such as the legs).

Impacting Social Presence

For MRHs to be effective, users must consider them socially present, and they must elicit realistic behavior. To determine to what extent our MRHs achieve these goals, we conducted two studies.[8]

Figure 2. A user (playing the role of a nurse) interacts with two ANDIs (*An*imatronic *Di*gital Animated Avatars) playing the roles of the patient's mother and a surgeon. The user can speak to the ANDIs, who speak and gesture to the user. Unknown to the user, a human controls the ANDIs' responses.



(a) (b)

Figure 3. A team-training scenario. (a) A trainee interacts with completely virtual team members (low physicality). (b) A trainee interacts with MRHs sharing the same physical space (high physicality). The results suggested that increasing physicality increases the sense of social presence.

They employed the myocardial-ischemia scenario, but in this case, the participant interacted with two MRHs playing the roles of a nurse and the patient's daughter.

Unknown to the user, a human chose the speech and animation responses for the MRHs. A human operator avoided errors that might be introduced by an AI system or a speech recognition system. Whereas future research will explore replacing the human operator with an AI system, this initial research explored what types of team-training scenarios and learning objectives are addressable using MRHs.

The first study investigated the importance of bringing the virtual human into the user's physical space. In it, 23 residents interacted with either virtual humans on a wall display (see Figure 3a) or MRHs (see Figure 3b). The first situation exhibited low physicality; it created the sense that the virtual humans inhabited a virtual space adjacent to the physical space. The second situation exhibited high physicality; it created the sense that the MRHs inhabited the same physical space as the user.

Our results suggest that increasing physicality increases the sense of social presence. However, the participants reported different social-presence results for the nurse and daughter characters. This difference might have been due to the relationship between physicality and plausibility. Increasing the physicality generally increases the social presence, but expectations of the MRH's realism also increase. Thus, if an MRH's realism and plausibility are insufficient, the social presence decreases. Participants reported that the daughter's presence and conversation weren't realistic, owing to technical issues, poor-quality animation and audio, and an unrealistic script. So, as that MRH's physicality increased, its social presence decreased.

In the second, follow-up study, 32 nurses participated in a training session with the MRHs. We employed a 2 × 2 design study in which the independent variables were a "see-through" display (with a realistic background) versus a display with a black background, and physical props versus no physical props. We evaluated how the virtual component (the see-through display) and real components (the physical props) affected the MRHs' social presence.

Our results suggest that both the see-through display and the physical props significantly increased social presence, with the see-through display affecting the increase more. We anticipate that this increase will result in more realistic user behavior and, in turn, more effective training.

Communication Skills Training

Our research has led to an infrastructure for a sustainable environment for teaching team skills to OR nurses. As a result of our studies, every OR nurse at the University of Florida Health hospitals must take MRH-based team training. Nurses practice team-training scenarios every six months.

In these scenarios, the nurses are expected to review and experientially apply best practices to information exchange. They're also expected to speak up, stopping a procedure if teammates violate protocol and endanger patients. The nurses have reported that the scenarios are realistic. They've also reported that the experience is a safe environment to practice skills that are difficult to effectively apply in the fast-paced environment of the OR. Planned studies will evaluate how practice with MRHs improves effectiveness in real environments.

We plan to expand the team sizes being simulated. As we mentioned before, we'll also explore how to automate multiparty interactions with natural-language-processing algorithms, AI, and expert systems. In addition, we'll try to quantify MRH-based team training's benefits. Finally, we hope to disseminate the technology to other groups for other training applications.

References

1. J.H. Chuah, "Identifying and Exploring Factors Affecting Embodied Conversational Agent Social Presence for Interpersonal Skills Training," PhD dissertation, Univ. of Florida, Gainesville, 2012.
2. L.T. Kohn et al., eds., *To Err Is Human: Building a Safer Health System*, National Academies Press, 2000.
3. M. Zwarenstein and S. Reeves, "Working Together but Apart: Barriers and Routes to Nurse–Physician Collaboration," *Joint Commission J. Quality and Patient Safety*, vol. 28, no. 5, 2002, pp. 242–247.
4. T.W. Reader et al., "Developing a Team Performance Framework for the Intensive Care Unit," *Critical Care Medicine*, vol. 37, no. 5, 2009, pp. 1787–1793.
5. C.-J. Wallin et al., "Target—Focused Medical Emergency Team Training Using a Human Patient Simulator: Effects on Behaviour and Attitude," *Medical Education*, vol. 41, no. 2, 2007, pp. 173–180.
6. S.K. Rothschild and S. Lapidos, "Virtual Integrated Practice: Integrating Teams and Technology to Manage Chronic Disease in Primary Care," *J. Medical Systems*, vol. 27, no. 1, 2003, pp. 85–93.
7. S. Lampotang et al., "Mixed Simulators: Augmented Physical Simulators with Virtual Underlays," *Proc. 2013 IEEE Virtual Reality* (VR 13), 2013, pp. 7–10.
8. J.H. Chuah et al., "Exploring Agent Physicality and Social Presence for Medical Team Training," *Presence: Teleoperators and Virtual Environments*, vol. 22, no. 2, 2013, pp. 141–170.

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