The Virtuality Continuum Revisited

Anton Nijholt
University of Twente
Enschede, Netherlands
anijholt@cs.utwente.nl

David Traum
Institute for Creative Technologies
USC, Marina del Rey, USA
traum@ict.usc.edu

ABSTRACT
We survey the themes and the aims of a workshop devoted to the state-of-the-art virtuality continuum. In this continuum, ranging from fully virtual to real physical environments, allowing for mixed, augmented and desktop virtual reality, several perspectives can be taken. Originally, the emphasis was on display technologies. Here we take the perspective of the inhabited environment, that is, environments positioned somewhere on this continuum that are inhabited by virtual (embodied) agents, that interact with each other and with their human partners. Hence, we look at it from the multi-party interaction perspective. In this workshop we will investigate the current state of the art, its shortcomings and a future research agenda.

Author Keywords
Multi-party interaction, virtual reality, smart environments.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
More and more we see the need to model multi-party interaction in the interface. Interactions take place in environments rather than in the traditional human-computer interface and in these interactions different actors are involved, both human and non-human. Environments, e.g. a smart meeting room or a desktop storytelling environment, require the modeling of multimodal interaction: interactions between human users, the environments and objects represented in the environments, and (embodied) conversational agents that represent human users or that have been designed to play particular roles in the environment. Traditionally, an agent plays the role of an information or navigation agent, plays the role of a meeting assistant in a virtual meeting environment, or plays the role of an actor in a virtual storytelling environment. However, in many environments, rather than interacting with one particular user they need to interact with different human and also other synthetic agents, they need to know about the properties (personalities, intelligence, emotions, capabilities, etc.) of these different agents, they need to know who is aware of what they are saying or doing, and they need to maintain a model of the multi-party dialogue between the different agents. It becomes necessary to compare research approaches on agent interaction modeling in virtual, mixed-reality and real (physical) environments. For these environments, interaction modeling means multimodal (verbal and nonverbal) interaction modeling and it means (1) modeling human behavior and human – human interaction behavior, (2) modeling human and virtual actor behavior and human – virtual actor behavior, and (3) modeling behavior of virtual actors and virtual actor – virtual actor behavior. In addition, it is possible to talk about different types of audience involvement, that is, virtual and real people that mainly observe but may be given the opportunity to influence the activities by their presence and their reactions.

Presently, research on multi-party interaction in spaces where temporal and spatial relations play a role is hardly touched upon, although there are exceptions [3]. On the other hand, more and more we see research projects touching upon these topics and for that reason it is useful to make the attempts to enter this area of research explicit. Clearly, when talking about virtual actors we can as well talk about smart objects, smart graphics, and interactions with a smart or ambient intelligence environment. In fact, we are looking at the so-called virtuality continuum.

VIRTUALITY CONTINUUM
The concept of the virtuality continuum was introduced in the literature by Milgram and Kishino [1]. In the previous section we already alluded to this concept. In Figure 1 we illustrate this continuum from full reality to full virtuality.

From left to right there is an increasing degree of computer-produced stimuli. At the extreme right we have immersive virtual environments where all stimuli are computer generated. We can also look at this continuum from the point of view of smart environments and multi-party interaction. A real environment can have human inhabitants that interact with each other. They see and hear each other and can understand the interactions taken place and the behavior of the inhabitants of the environment. Turning this environment into a smart environment requires the

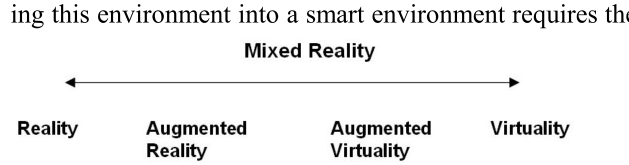

Figure 1: The virtuality continuum

CHI 2005, April 2–7, 2005, Portland, Oregon, USA.
ACM 1-59593-002-7/05/0004.

distribution of (smart) perceptory devices throughout the environment allowing the environment to keep track of locations, activities and interactions and provide support, anticipating what the inhabitants need. Making use of these devices smart objects and smart interface agents can be designed that can both address human inhabitants of the environment and that can be addressed by the human inhabitants of the environment. Agents can get human-like embodiment, that is, we can have virtual humans taking part, using appropriate display technology, in activities and collaboration with human users and inhabitants of the environments. These virtual humans can either be fully synthesized and autonomous, they can real-time represent humans that remotely visit, meet or work in the environment, or they can be something in between. And, of course, they can be made to interact with partners in the environments. This allows us to look at the virtuality continuum from a multi-party interaction point of view.

MULTY-PARTY INTERACTION

Hence, rather than look at this continuum in terms of display technologies, we take a broader point of view: interaction made possible by agent and display technologies. Virtual agents that co-inhabit our mixed reality environments need to be able to interact among themselves and with their human partners in such a way that they live up to expectations concerning their behavior, and their emotional, social and rational intelligence [2].

What need to be modeled when we put human and virtual agents in the virtuality continuum? Many issues need to be discussed: appearance, behavior, intelligence, emotion display, gestures, facial expressions, posture, etc. However, this external nonverbal behavior can be generated, using graphics and animations, from internal models of individual agents and from models of interaction between agents, whether they are human or synthetic. Assuming being able to display and animate virtual humans in a sufficiently believable way, we should concentrate on the role of interactions between humans, humanoids that represent and mimick humans and semi-autonomous and fully autonomous agents that inhabit worlds positioned along the dimensions of the virtuality continuum.

Without making any distinction, for the moment, between the different types of agents that can inhabit a world somewhere along the dimensions of the virtuality continuum, it is clear that we need models of multi-party interaction [3] rather than models of traditional human-human or human-computer interaction. Being able to model the external display of verbal and nonverbal interactions using interaction acts, interaction history, and interaction representation theory, requires, at a deeper level, the modeling of the beliefs and aims of the individual participants (human or virtual). Apart from contextual constraints that guide the agent's reasoning and behavior, there are constraints on behavior that follow from general models that describe emotions (emerging from an appraisal of events). Examples of appraisal variables are desirability, urgency or unexpectedness. Causal attribution is another issue (who should be blamed or credited) and so is the coping potential. In current research it is also not unusual to incorporate a personality model in an agent to adapt the appraisal, the reasoning, the behavior, and the display of emotions related to personality characteristics.

Clearly, human and virtual agents involved in multi-party interaction not only have goals that follow from short-term and individual benefits that can be reached, but they can also take into account goals that are pursued by a community of agents and they can also take into account social relationships that exist between agents. When we talk about goals of a community of agents, we need to talk about cooperation between agents and how social relationships influence cooperation. Clearly, agents can be designed to be responsible, helpful and cooperative. While acting in a virtual environment they can take into consideration their own benefits, the benefits of society or the benefits of both themselves and the society. It means that they need to get involved in social decision-making and they need to be aware of the effects of their acts with respect to themselves and their society. In these situations an agent needs other agents to achieve its intended goal and so social dependencies become important as well.

GOAL OF THE WORKSHOP

- Introduce the virtuality continuum in its current state of the art from the perspective of multi-party interactions between virtual and real humans;
- Discuss theoretical models that integrate theories from linguistics and nonverbal (gaze, turntaking, addressee detection) communication;
- To discuss a research agenda, including the identification of social interaction theories and applications in entertainment, education, simulation and training.

We hope to attract researchers from a wide range of disciplines, including HCI, Computer Science, AI, Graphics and VR, Simulation, Psychology and Social Science.

REFERENCES

1. P. Milgram and F. Kishino. 1994. A Taxonomy of Mixed Reality Visual Displays. *IEICE Transactions on Information Systems.* vol. E77-D, no. 12, Dec. 1994.
2. A. Nijholt. Where computers disappear, virtual humans appear. *Computers and Graphics*, Vol. 28, No. 4, Elsevier, 2004, 465-476.
3. D. Traum & J. Rickel. Embodied agents for multi-party dialogue in immersive virtual worlds. In: Proc. 1 Int'l Joint Conf. on *Autonomous Agents & Multi-Agent Systems* (Vol. 2), 2002, 766-773.