Measuring Presence in Augmented Reality Environments: Design and a First Test of a Questionnaire

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Introduction

Augmented Reality (AR) enriches a user's real environment by adding spatially aligned virtual objects (3D models, 2D textures, textual annotations, etc) by means of special display technologies. These are either worn on the body or placed in the working environment. From a technical point of view, AR faces three major challenges: (1) to generate a high quality rendering, (2) to precisely register (in position and orientation) the virtual objects (VOs) with the real environment, and (3) to do so in interactive real-time (Regenbrecht, Wagner, & Baratoff, in press). The goal is to create the impression that the VOs are part of the real environment. Therefore, and similar to definitions of virtual reality (Steuer, 1992), it makes sense to define AR from a psychological point of view: Augmented Reality conveys the impression that VOs are present in the real environment. In order evaluate how well this goal is reached, a psychological measurement of this type of presence is necessary. In the following, we will describe technological features of AR systems that make a special questionnaire version necessary, describe our approach to the questionnaire development, and the data collection strategy. Data are currently collected, and results will be presented at the workshop.

Technology and Type of Presence

AR systems can be categorized regarding the display and interaction technology used as well as the reference relationships between real world, virtual (augmented) world, and the user's body or body parts (esp. hands). In addition to that one should distinguish between single and multi user applications. Widely used are systems with an HMD as a display device, either as an optical-see-thru system, where the user is looking through the glasses of the HMD into the real environment, or video-see-thru systems, where the real world is mediated by a video stream captured by a head-mounted mini camera. The whole system can be used in a stationary setup or as a wearable technique (Azuma, 1997). A second category of AR systems uses (stereo) projection techniques (e.g. CAVE-like environments, stereo projection screens) in addition to real world objects (e.g. Bimber et. al., 2001). A third category uses hand-held devices with a Through-the-lens metaphor to augment VOs onto the real environment seen through the display (Regenbrecht & Specht, 2000, Mogilev et. al., 2002).

Although from a technical perspective these systems are very different, they share a common feature, namely that it is the real environment that the VOs are placed in. Therefore, the common approach to measure presence in virtual environments, questions on the experience whether one has the sense of being there in the VE, does not work. AR elicits a different sense of presence: "It is here" presence (Lombard & Ditton, 1997). We know of no previous attempts to develop a scale for this experience.

Questionnaire Development

We have developed a first version of a questionnaire to measure the experienced presence of VOs in the real environment. Our approach was based on a previous theoretical model of presence in virtual environments that is easily generalizable to presence of VOs in augmented reality (Schubert, Friedmann, & Regenbrecht, 2001). We argue that presence of VOs develops when we mentally represent bodily actions on the VOs as *potential bodily actions*. In order to develop these representations, it is necessary to devote attention to them and actively construe them on the basis of their visual representation. Related to the experience that the VOs are present in the real space, but by no means identical to it, is the experience that they achieve a certain sense of realness (Banos et al., 2000). In our previous research, we have found that presence and realness judgments differ, and that they are predicted by different variables (Schubert, Friedmann, & Regenbrecht, 1999).

On the basis of this reasoning, we developed items that assessed (a) the experienced presence of VOs in the real space, (b) experienced co-location of VOs and body in the same space, (c) experienced realness of the VOs, (d) synaesthetic experiences and behavioral confusion, as well as (e) experienced control over the interaction and (f) experienced effort for mental construal. We also added items on previous experience with similar technologies and enjoyment of the interaction. After a first round of data collection with the technologies mentioned below (N=16), items with very low variance were excluded. Although preliminary, these data already suggested that the division between presence and realness also holds for AR.

Data collection

The final questionnaire, with 26 questions related to facets (a) through (f), is currently applied to users of four different applications, out of each of the realms described above: 1) HMD-based single user application "MagicDesk" (Regenbrecht, Baratoff, & Wagner, 2001), 2) the interactive two user Through-the-lens demonstration "AR Pad" and HMD-based "MagicMeeting (Regenbrecht & Wagner, 2002), and 3) the single/multi user projection system "IllusionHole" at Bauhaus University Weimar. These applications feature the following interactions: *MagicDesk*: In front of an HMD-wearing user stands a turnable plate (CakePlatter) on a table with a virtual scaled car model on it. Using a pointing device with a knob on it the participants can texture car parts (like door or roof) by pointing a virtual ray towards the desired part and pushing the button. The texture to be used currently is "photographed" with a knob on the HMD before. *AR Pad*: Two user, each holding a LCD screen with a camera attached to it. Mounted to this device is a "SpaceOrb" device for 3DOF rotation and selection. The users sit vis-a-vis on a table. Between the users textured cubes are placed in virtual (augmented) space. Each side of a cube is textured different. The task is to puzzle in 3D. *MagicMeeting*: This is the collaborative version of MagicDesk, in our case a two user version. The users sit side by side on the same table looking onto one shared model with collaborative interactions. The interaction tasks are lighting the model, a real transparent acryl clipping plane (virtually clipping the model) and annotation cards to color the model. *IllusionHole*: Between one and four users look at a large horizontal screen, wearing shutter glasses. The position of their heads are tracked. Each user sees a specific part of the screen, on which the VOs are presented correctly aligned for his or her perspective. The partition of the screen space is reached by a hole in a plane placed above the screen. The hole is a circle, with a diameter of approximately 20 cm. The VOs appear to flow in the space left by the hole, and extend up to 10 cm below and above the hole. Participants can interact with the objects using tracked pens.

In each environment, users interact at least 5 minutes with the environment. Because of the very simple and natural interfaces no detailed instructions are needed. Participants can use the systems immediately. We currently collect data using the questionnaire and will present results from principal components analysis and regressions on the other measures at the conference. We will especially discuss (a) the relation between "it is here" presence and realness, (b) the relation to the experienced control over the interaction, and (c) the similarities and differences to presence in virtual environments.

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