An Augmented Virtuality Approach to 3D Videoconferencing

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Abstract

This paper describes the concept, prototypical implementation, and usability evaluation of an Augmented Virtuality (AV) based videoconferencing (VC) system: "cAR/PE!". We present a first solution which allows three participants at different locations to communicate over a network in an environment simulating a traditional face-to-face meeting. Integrated into the AV environment are live video streams of the participants spatially arranged around a virtual table, a large virtual presentation screen for 2D display and application sharing, and 3D geometry (models) within the room and on top of the table.

1. Introduction

Favored by the boom of the Internet and by an increasing number of worldwide merger and acquisition activities, global communication did not only increase in volume, but eventually created a technically advanced and actually working communication network. A distant computer supported collaborative work (CSCW) environment is on its way to an international scale.

Therefore there is a strong need for tools that support and enable easy-to-use communication between distant partners.

Based on the idea of our Augmented Reality system "MagicMeeting" [2], which allows a number of four (but not limited to 4) participants to discuss virtual 3D geometry on a physical table using distributed AR technology we have developed a prototype Augmented Virtuality system "cAR/PE!" for remote collaboration.

Compared to other CSCW and AR approaches (like [8], [9]) the novelty of our approach lies in the integrative combination of 3D videoconferencing, reality-like communication features, presentation/application sharing, and 3D-model display within one environment. The underlying use scenario derives from an industrial context to enable global engineering. Two or more engineers are conducting a meeting. During this meeting they can discuss changes or improvements to 3D objects derived from CAD data. A more complex application scenario is the manipulation of these 3D objects (turning and moving, annotating, clipping through, lighting, assembly and disassembly). Since the objects are virtual, the engineers do not have to meet in one location. Like in a real meeting additional documents are needed for a comprehensive discussion: a slide presentation for the agenda, goals, details etc., an application sharing capability to discuss details in e.g. the CAD system normally used, text and spreadsheet document display or a possibility for documentation. Using cAR/PE! the engineers sit in their regular office with access to their documents and computer systems, not having to leave their workstation like with video conferencing facilities.

2. Implementation

Our implementation of the system connects multiple cAR/PE! stations (off-the-shelf PC with TFT-display, camera, audio head-set, and SpaceMouse 6DOF controller, see figure 1) to an Ethernet network. The network is divided into four channels: (1) a video channel transmits the video data of the participants, (2) the audio channel transmit the voice streams, (3) the interaction channel is the carrier for all kind of interactions by the users, for the initiation and synchronization of the stations, and for the transmission of the application sharing data, (4) the 3D data channel is used to initially distribute the geometry of the cAR/PE! room itself, for the initial distribution of the 3D models to be discussed in the meeting, and for changes or ad-hoc distributions of 3D models. To avoid network overload immediately prior to or during the meeting all already known data (especially 3D) are distributed beforehand. These data are stored locally at each station. The stations are connected point-to-point. We chose this option for security and infrastructure reasons.

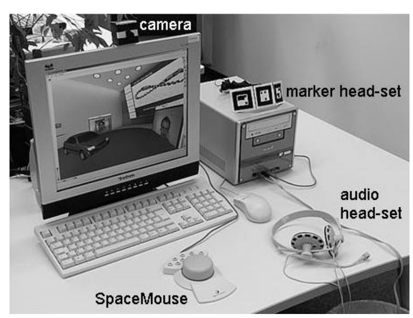

Figure 1. cAR/PE! hardware setup

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The software is based on our in-house VR/AR framework, which is implemented on top of OpenInventor. It was extended with special functionality especially regarding video and audio streaming, user interaction, and data and process integration into workflows already present in the target users contexts.

The shared virtual environment seen by each participant from the appropriate perspective, the "cAR/PE!"-room, is sketched in figure 2.

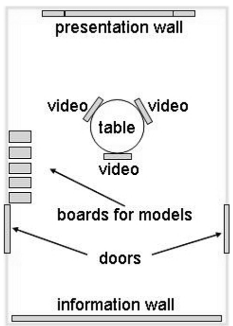

Figure 2: schematic overview of cAR/PE! room

The presentation wall is intended for application sharing and presentation slide display. For better visibility the wall is slightly tilted. In the center of the virtual table 3D models can be placed (see figure 3). All 3D models to be presented are shown on the left hand wall. The information wall shows live video streams of each participant as well as status information.

This room (model geometry) serves as a first test bed and can be substituted by alternatives by simply loading other (OpenInventor/VRML) files.

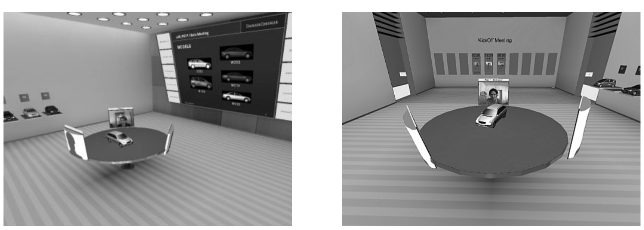

Figure 3. different inside views

Figure 4. visible viewpoint control

Each participant can change his/her view into the virtual environment using the SpaceMouse in combination with a "fishtank VR" like interface (the display-mounted camera tracks the users head movement in front of the display). Both movements are transmitted to the other participants and control the orientation of the video plane (see figure 4). With this approach the user can see where the other participants are looking at.

3. Results

Until know we have conducted two usability studies. Study #1 was examining the general usability of our approach while study #2 focused on task measurements regarding effectiveness and efficiency. The second study took place with engineers (planning and design) in one of our production plants. First results show the general usability of the system and a surprisingly high user satisfaction. They actually were able to communicate over distance and get engineering discussion tasks done successfully. We are going to develop this prototype towards a system for operative use within our enterprise context. On the basis of our current prototype system we are going to improve the system performance and functionality with focus on bandwidth optimization, user interaction, and tight data coupling to existing systems (like product data management).

All future work is accompanied with usability studies targeting more detailed questions like interaction and communication in an AV environment.

Although this is a first prototype system our general concept and the actual setup implemented are very promising. We believe that we can come up with a productive system within the near-term future.

4. Acknowledgements

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5. References

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