Virtual Reality Environment with Shared PC and Live Video Streaming for Computer-Supported Collaborative Learning

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Abstract—
This paper presents a approach to a multi-user virtual reality remote collaboration system for workshop-like events. It addresses a wide area of problems occurring in conjunction with workshop events. Distributed multi-user related problems like interaction and shared resources are also covered. The collaborative environment introduced here allows simultaneous usage of a shared 'virtual computer' in a team. The group is able to interact via non-verbal communication (gestures) and to discuss the results of their work via text-chat. A real collaboration like in local seminar events is possible. They control the seminar-environment exclusively with their standard web browser. The remote seminar room is based on a multi-user virtual reality client/server architecture, called DeepMatrix, which is implemented in the Java programming language. The used components are mainly based on standards like VRML and Java.

I. Introduction

The University of Hagen is the first and only university in German-speaking countries, which is (almost) exclusively based on distance teaching methods. As one of the largest universities in Germany it provides university-level education and related degrees. About 80% of the students are already professionals who study mainly in the evening and on weekends. The Internet becomes increasingly important as a medium for knowledge distribution and even as a learning environment. To provide our students, who are geographically distributed all over Germany and Europe, with synchronous communication facilities, we have developed a collaborative virtual reality environment for workshop-like events. It is based on similar techiques like our virtual reality based experimentation enviroment [2].

II. Requirements

Although the University of Hagen is a distance teaching university, the typical today seminar event is still a synchronous event. Usually the students have to travel to Hagen for these kind of events. To avoid the effort of time and money for the students a synchronous communication feature is highly desirable. As a future perspective of a distance teaching university, even a development towards a 'Virtual University' is thinkable, which should be completely Internet-based.

Asynchronous virtual workshops (seminars) are taking place at the University of Hagen since 1996 [14]. But asynchronous events have some disadvantages regarding collaboration in a group. To provide a synchronous seminar-like environment to a group of students, typical synchronous communication techniques like video-conferencing are not suitable because of bandwidth limitations. A video-conference with more than two communication partners is a typical point-to-multipoint application. If a true collaboration of all partners is desired, the partner with the smallest bandwidth limits the communication. Our application requires real interaction between the students and the tutor, so a bandwidth-saving way of interaction is required as an alternative to the video based communication. Pure text-based communication (chat) does not meet our requirements because a multi-user virtual synchronous seminar application needs the possibility of real interaction. In a 3D-chat an *avatar* tries to mimic the behavior of the user in virtual reality. An *avatar* is the representation of a real person in virtual reality. The *avatar* plays the role of the video in a video-conference. Participants can see other users as in a real world scenario. It is possible to provide the user avatars with some simple gestures to visualize for instance 'agreement' or 'disagreement'. 3D-chats have lesser bandwidth requirements than video-conferences, because only events are transmitted. A comparative summary of the different standards for collaborative environments is given in [9].

III. Virtual Environment

To provide the students with a realistic environment for a virtual seminar event, a well known seminar room of the University of Hagen was modeled in VRML (**V**irtual **R**eality **M**odelling **L**anguage). On the client side, VRML is used to display the virtual 3D environment. VRML as a text-based language is a powerful, nevertheless simple language to build 'virtual worlds', which include 3D objects, light sources and animations. This virtual room is equipped with a virtual beamer and screen, to render a live audio/video stream (e.g. a lecture) or the desktop of a shared computer. The introduced multi-user virtual reality seminar environment [7] consists out of the underlying DeepMatrix [5] Java-based client-server system, an interface to the existing 'virtual-university'-user-database of the University of Hagen, a streaming video Application (Real-Server, Real-Producer) and the opensource '**V**irtual **N**etwork **C**omputing' (VNC)-tool.

A. Communication middleware

The communication middleware is based on the open-source (a special license, free for educational usage) VRML-Multi-User-Software DeepMatrix which implements its functionality by Java-VRML coupling. VRML specifies an External Authoring Interface (EAI) which can be used by external java-based applications to monitor and control the VRML environment. This is used to update the virtual world with the positions of the other user avatars. DeepMatrix itself is a pair of client and server software implemented in Java [13]. The server is implemented as a Java application which communicates with all clients and provides them with updates of the 3D-scene. The client applet controls the local VRML-browser-plug-in via the EAI to update the scene (the positions of other avatars) and senses the local user movements to send new positions to the server.

An additional DeepMatrix client, based on Eyematics Shout3d [4] Java 1.1 based VRML rendering engine, provides an own API for Java-VRML coupling. Since the Shout3d VRML-rendering applet is pure Java based, some caveats like slower 3D-rendering (the **J**ava **V**irtual **M**achine is not allowed to use the clients graphics hardware acceleration) and the implementation of a subset of the VRML standard must be accepted. The most important advantage of the DeepMatrix-Shout3d client is the unnecessary VRML-browser binary, no additional software must be installed on the client computer(platform independent). The original Geometrek implementation of the Shout3d based clients does not allow any interaction between users of the VRML-browser based and the Shout3d based clients. We have modified the Shout3d-based client to provide shared rooms for users of both clients. Due to the limitation of the Shout3D VRML inplementation avatar gestures and streaming video rendering inside the 3D-window are not realized.

B. User authentication

Seminars at the University of Hagen are usually part of an examination, so an authentication procedure is required. The DeepMatrix-client-server system is initially intended for anonymous 3d-chat. Nevertheless the opensource distribution of the DeepMatrix allows modifications to the Java-sourcecode to provide a connection to the existing LDAP-directory service at the University of Hagen. This modification is very convenient for the users because no extra passwords and administrational effort is necessary. LDAP, the Lightweight Directory Access Protocol was proposed in 1995 (RFC 1777) as an open standard for directory services on the Internet. The virtual university environment of the university of Hagen [8] (platform 2001) is based on LDAP.

The user authentication names for students of the University of Hagen are usually numbers. To provide a convenient interface for the learning group and the tutor, real names of the user are also fetched from the directory server database.

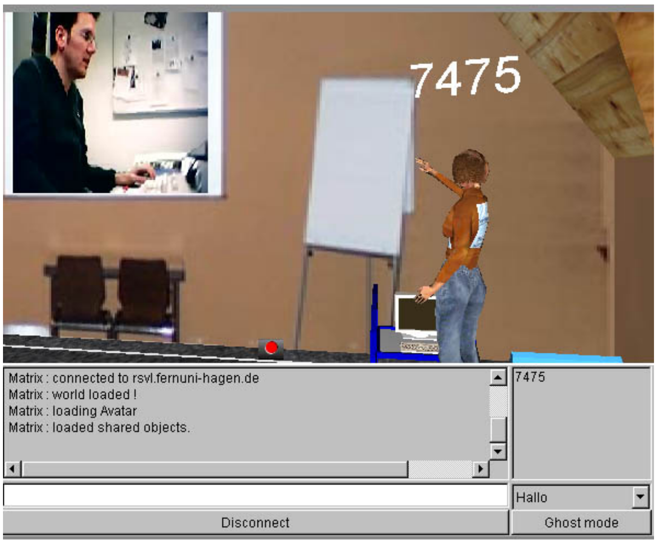

Fig. 1. Streaming video embedded into the VRML environment

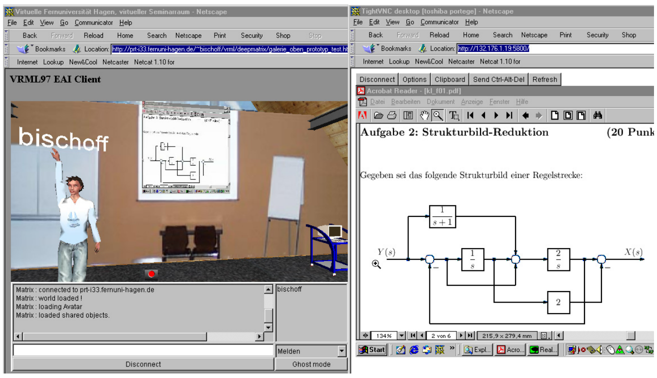

Fig. 2. Web-based shared PC integrated into the VRML environment

C. User avatars

All the remote users are represented by realistic human avatars. Every user is able to control gestures of his avatar. Some of these avatar-gestures are especially adapted to a typical classroom situation, e.g. 'put one's hand up' and 'point to', to provide non-verbal communication to the users. This virtual environment is equipped with a virtual beamer and screen, to render a live audio/video stream (e.g. a lecture) or the desktop of a shared computer.

D. Streaming video

Today's VRML-browsers like Blaxxun Contact [3] and Parallelgraphics Cortona [10] are able to display Real-live-stream inside the VRML-world, if the Real-Player is installed onto the client-computer, so the streaming video could be used as a video-beamer application inside the modeled VRML-room.

The streaming audio/video (beamer) feature is realized by the usage of commercial software tools. The Real-Producer[11] tool is used to record live video/audio and to stream the data to the Real-Server[11]. The server-tool is necessary because the server is able to handle concurrent requests to the stream with different transmitting rates. The only requirement on the client side is a installed real-player[11] web browser-plug-in. The provided video and audio quality is very usable for low-bandwidth connections due to the high quality video and audio compression codecs of the Realnetworks products. The only caveat of the used compression codecs is the high delay (usually more than 10 seconds)of the live-stream. The quality of the Realnetwork codec is in fact so high, because the compressing algorithm is able to look ahead the intended delay time. Therefore the Realnetworks products are not usable for real-time applications like online experimentation[6]. For this kind of applications Java-Media-Framework (JMF)[12] is more suitable. A delay of 10 to 20 seconds is usually tolerable for online seminar events.

E. A shared virtual computer

To provide the users with a kind of a whiteboard an universal solution was selected. Not only Presentation-software like PowerPoint is frequently used to explain topics to a group of users. In different disciplines user-groups need different software-tools, or operating systems during seminar events. A universal solution is a shared PC, simultaneously useable to all participants. A platform independent solution for simultaneously remote control of computers is the open-source '**V**irtual **N**etwork **C**omputing' tool developed by the AT&T Laboratories in Cambridge[1]. The HTTP-server which is part of the VNC-server utility is running on the shared seminar computer, and provides a Java applet to the client computers, which displays the desktop content of the shared computer in a web browser-window. All the connected and authenticated users are able to remote control all installed applications. Documents and binaries can be uploaded easily to the shared computer via standard e-mail attachment. The screen resolution an color depth should be reduced to 640x480x8 due to bandwidth limitations of remote modem users.

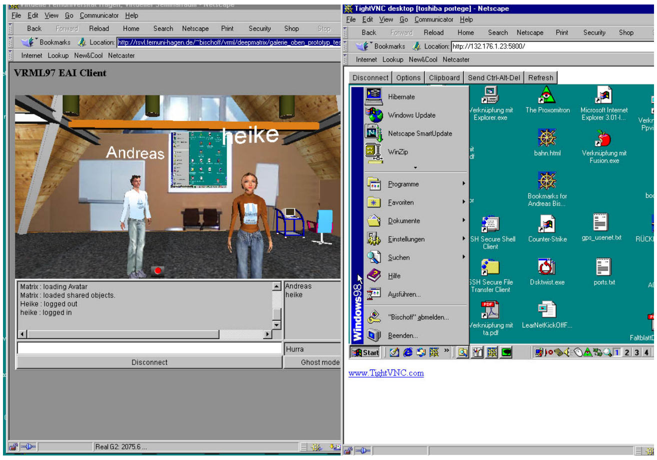

Fig. 3. An example for an universal shared application: Windows desktop

IV. Conclusion

The contribution shows that distance education methods can be applied to workshop-like synchronous events. Even collaboration in a team is possible. Remote users interact and discuss the results of their work. A real collaboration like in local workshops is possible. In the opinion of the authors such functionality justifies the usage of avatars in education. On the client side, there are only some minor requirements. Students are able to use the experiments with a Web browser and Java runtime environment. The server exclusively uses software that is available for free. All the components are usable through a low bandwidth modem (56kbit/s) or ISDN-connection. The virtual reality collaborative environment without live-video-stream a shared remote PC, is still usable under 'worst case' conditions, like a 9600 Baud GSM-mobile-phone-connection. A similar virtual reality collaborative environment is in use since 2001 for online remote experimentation.

V. Future Work

The evaluation of the introduced environment is outstanding and will be happen during summer 2003 with groups of students of various disciplines.

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