Immersive Whiteboards
In a Networked Collaborative Environment

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Abstract

An immersive whiteboard system is presented in a networked collaborative environment where users at multiple locations can communicate with each other. The immersive system consists of five major components: the network, the virtual environment, the avatar representation, the multimedia objects, and the shared whiteboards. The virtual environment is shared among multiple networked users and allows each user to interact independently with the world. The avatar is used to represent each user in the immersive environment and conveys its user identity and facial expressions to the world. The shared whiteboards provide a medium for communication using handwritten inputs, as well as a desirable interface for navigation and mouse control. The goal of this immersive system is to provide a convenient environment for participants to interact with each other. The system is suitable for distance learning and conferencing applications because it uses the whiteboard interface and provides a user avatar representation for any virtual environment.

1. Introduction

When a group of people gets together in one room to work on an agenda, we refer to this scenario as an ideal collaboration. A collaborative system can thus be viewed as a collection of technologies enabling users at multiple locations to seamlessly communicate with each other and to work jointly on the object of interest. To determine the desired technologies for our collaborative system, we examine existing collaborative and conferencing applications.

Current video conferencing systems, such as Microsoft NetMeeting and CU-SeeMe [1], lack the sense of immersion because each user sees the other users in separate windows; thus it is often difficult to tell who is talking to whom. Furthermore, Argyle and Dean [2] suggest that during communication people vary physical proximity, eye contact and other behaviors to optimize an overall level of intimacy. This suggests that an immersive environment where users can navigate and interact offers the best setting.

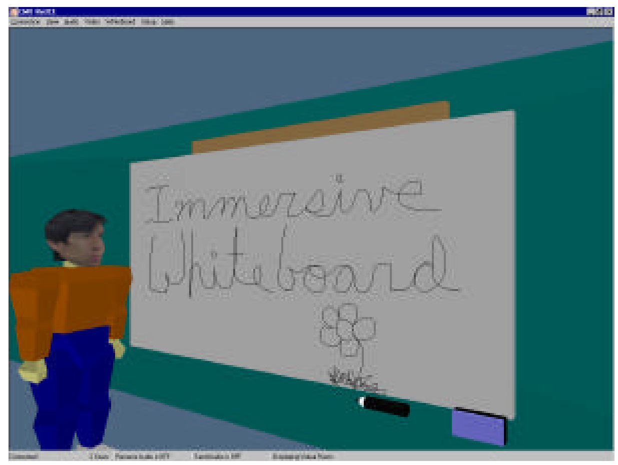

Figure 1. Immersive Whiteboard System.

To identify the users in this virtual environment, avatars are required to represent each user. In Interspace [3], the avatar's face is merely a 2D image resulting in perspective distortion when viewed in a virtual environment. For a realistic representation of each user, the avatar is synthesized from the user's head. Furthermore, facial expressions, lip synchronization, hand gestures, body movements and user locations should be implemented features of the avatars.

For users to communicate with each other, text may be the easiest form of input/output, but it is often hard to express the emotions behind it. An improvement is the use of audio in teleconferences. Other enhancements are images and video for physical objects. Furthermore, the use of whiteboards has been found as a beneficial medium to exchange spontaneous handwritten ideas. Subsequently, our system will use the 3D environment to share different multimedia objects among the users. Figure 1 shows a user using the whiteboard to communicate with others in the immersive world. In this paper, a networked environment using multi-modal media is integrated with shared whiteboards to achieve our goal for seamless and spontaneous collaboration.

The rest of the paper is organized as follows. Section 2 provides a system overview and the five components of our collaborative whiteboard system. Section 3 describes the setup environment for our system using physical whiteboards and a brief review of NetICE. Section 4 focuses on the virtual environment while section 5 concentrates on the avatar representation. Section 6 describes how the shared whiteboards bring together the interface for the whole collaborative system. Section 7 proposes some applications including our implementation of a virtual auction house. Finally, Section 8 provides a summary of our immersive whiteboard in a networked collaborative environment.

2. System Overview

Our immersive whiteboard system is built upon five technologies to provide for a networked environment where users at multiple locations can work with each other and interact with available objects. Figure 2 shows five technical components to achieve our goal and their main contributions to the overall system.

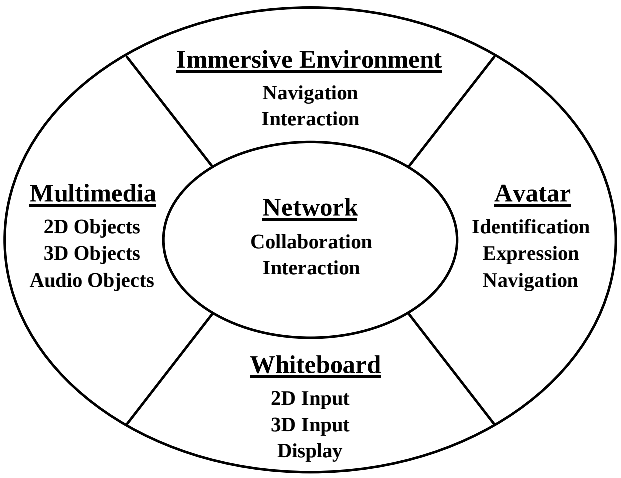

Figure 2. Five Technical Components of Our Networked Collaborative System.

The first underlying requirement is a network where users at different locations can connect with each other. The second technical component is the immersive environment in which users share their presence and the objects on their agenda are exchanged. The 3D environment provides a common world for each user to be represented and for all multimedia objects to be displayed. The third component is the avatar representation of each user. The avatar serves as a form of identification, expression, and navigation.

The fourth technical component is multimedia used during collaboration to facilitate communication. Multimedia objects supported on our system include text, audio, images, video, handwriting, and 3D models. Finally, the fifth element of our system is the shared whiteboards. The whiteboard is both a physical platform for I/O interfaces and a virtual screen for sharing multimedia. Next section describes how the whiteboard efficiently pulls all five technologies together.

3. System Setup

The immersive whiteboard system can be better understood when the software and networking modules are described before the physical whiteboard setup. Most of the software and networking system is provided by NetICE, as summarized by Section 3.1. The physical setup describes the I/O interfaces and demonstrates how the physical whiteboard is used to fulfill those tasks. Section 3.2 explains how the whiteboard serves as both a physical and virtual medium.

3.1. NetICE System

The NetICE system [4] provides a transparent communication medium that is composed of two main components: the server and the client terminals. The network connects two or more users at their client terminals with the server so that the users think they are collaborating in the same room. The server is a centralized multi-point control unit that maintains the states of the system and distributes the received data streams back to the clients.

3.2. Whiteboard Setup

The physical setup of an immersive whiteboard suggests that each client have the following components:

- A typical whiteboard, as found in classrooms and offices.
- A computer with networking capabilities.
- A pair of audio speakers for spatial sound effects.
- A wireless microphone to capture user's speech.
- A projector to display the immersive environment.
- A stroke input device for capturing handwritings on the whiteboard, like the Mimio [5] or e-Beam.
- A pen corresponding to the stroke input device for writing on the whiteboard surface.
- Finally, a video camera for capturing the user.

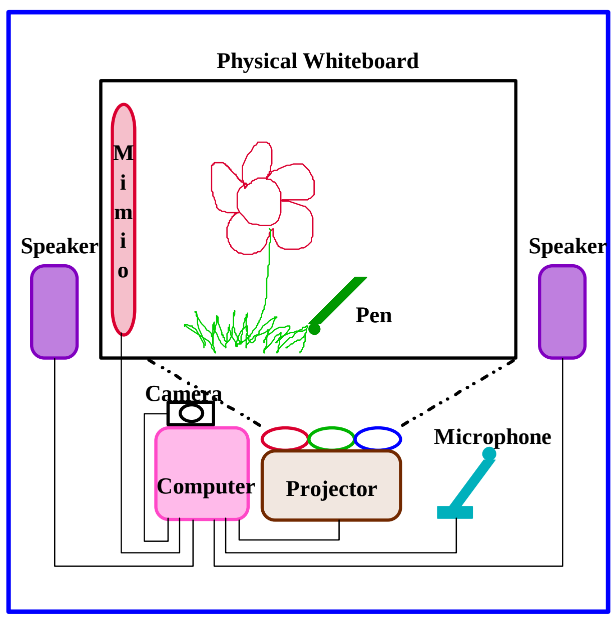

Figure 3. Physical Immersive Whiteboard Setup

Each equipment serves as an input or output device to the computer and the user uses them as interfaces within the immersive environment.

Figure 3 depicts the placement and configuration of the setup components listed above. First, align the projector so that it projects its images onto the physical whiteboard. Second, connect the projector to the computer display port. Third, attach the stroke input device on the whiteboard and connect the output line to the computer. We use the Mimio device. Next, station audio speakers for spatial audio and set up the wireless microphone to record the user's speech. Finally, hook up the video camera to capture the user.

The pen corresponding to the stroke input device is not an ink-writing instrument. Instead of leaving marks on the whiteboard, the pen position is send to the computer. The whiteboard system then displays virtual ink at that position on the computer, which in turn is projected back onto the whiteboard. This concept thus allows multiple users to contribute to the same whiteboard. The setup configuration of the physical whiteboard allows the user in front of the whiteboard to (1) view the virtual environment, (2) draw sketches, (3) control the mouse on the computer screen, and (4) navigate around the 3D world. Section 6 examines the full functionality of the immersive whiteboard.

4. Virtual Environment

The virtual world provides a common environment for users from multiple locations to gather together, meet each other, and collaborate on their interests. The NetICE server allows for customization and selection of a 3D world. After the server decides on the desired virtual environment, the 3D world model is shared with every connecting user. As a client connects with the server, a 3D avatar representation of the new user is positioned in the world and distributed to everyone else. Furthermore, multimedia objects added into the environment are shared with all users, via the centralized server.

Our world contains a dynamic whiteboard surface whose purpose is to provide a mean to display multimedia and call attention to points of interest. Users can place photo images on the board, present some prepared foils, play video clips or write equations on the whiteboard. Similarly, the virtual environment supports spatial audio sources at any 3D location providing a realistic and immersive environment.

The virtual environment provides users with a common space to communicate with each other, share multimedia objects, navigate around the immersive world, and interact with its objects. Our worlds include the following: avatars for each user, whiteboards for image/foil presentation and free hand drawing, and closed 3D rooms for concentrated activities. Figure 1 illustrates an avatar in front of a whiteboard attached to a wall of a room. In the next two sections, the avatar representation and shared whiteboards are described.

5. Avatar Representation

When a user enters an immersive environment, his/her presence is revealed as an avatar representation. This representation is crucial to other users in the 3D world because it serves as a unique form of identity and existence. Furthermore, advanced avatar representations may also convey expressions and moods with facial expressions and body gestures. In our NetICE prototype, the avatar representation features identification, expression, and navigation through realistic head models of the users.

In the realistic rendering of a user's head, the pre-generated avatar model is obtained beforehand. A customized 3D head model and corresponding texture map can be generated for a user by using a laser scanner, from multiple view photographs [6], or from a video camera [7]. Our work on realistic video avatar [8] uses images from the real-time video of the user to convey these facial animations. The customized realistic avatar is kept with the user until he/she connects with the server and loads the head model into the immersive environment as its identity. This allows others to easily identify the collaborators with their contributions.

The avatar representation of a user is essential for a networked collaborative environment. The identity of a user is revealed by its realistic head model. The expression or mood of the collaborator is demonstrated by facial expressions and body gestures. The navigation of the participants, and therefore their interests, is seen by others. Thus the avatar representation simulates the presence of each user in the 3D environment.

6. Shared Whiteboards

The shared whiteboards in the immersive environment provide the best medium for users to freely discuss handwritten and spontaneous ideas. On a conventional whiteboard, participants are expected to draw and see other people's drawings on the same surface. It offers a natural interface for both input/output and display. In our immersive whiteboard system, the whiteboard acts as a 2D stroke input, menu input, 3D object input, 3D navigation, and display.

Using the physical setup of the immersive whiteboard illustrated in Figure 3, the whiteboard acts as a display platform for computer. The Mimio input device captures the writing that occurs on the whiteboard surface and relays it to the computer. To find the correspondence between the point touched by the Mimio pen and the point on the computer, a simple calibration procedure is performed independently at each client. Note that the pen does not leave a marking on the physical whiteboard; only its actions are interpreted and displayed.

With this correspondence property between the writing instrument and the projected display, we can perform numerous desirable actions. First is the draw-on-whiteboard mode. When the virtual whiteboard directly corresponds to the physical whiteboard, the user can use the pen to write on the board. Whatever is drawn by the ink-less pen is rendered on the virtual whiteboard and shared with others [9]. Second, the menu-control mode uses the pen as a mouse-pointing device. The pen on the physical whiteboard can trigger the menus in our application. This allows users to control the whole application via menus at the convenience of the board surface.

The third mode of the whiteboard is the capability to insert 3D objects into the immersive environment. Similar to using the pen as a mouse pointing device, the pen can be used to drag-and-drop filenames into the application, including inserting 3D VRML objects into the virtual world. Finally, the navigational mode of the whiteboard allows the user to walk around and see the virtual environment. When the application is not in the draw-on-whiteboard mode, the pen acts as a navigational tool. After the pen touches the board, the direction of the stroke determines the direction and movement of the avatar. This mode is unanimously preferred over the use of keyboards for navigation in an immersive environment.

In conclusion, shared whiteboards in the immersive environment allow users to interact with their virtual applications. The physical whiteboard behaves as a display surface for the computer. The whiteboard also responds to pen strokes on its surface, which in turn is interpreted into one of several functions: draw on shared whiteboard, control application menus, insert objects into the world, and navigate around the virtual environment. These modes are conveniently performed on the surface of the physical whiteboard, while offering a natural pen interface for users uncomfortable with the rigidity of a computer keyboard or mouse.

7. Applications

There are several conferencing and collaborative applications that use whiteboards as a more natural medium to conduct discussions. Users are more comfortable with pens than with computer input devices and whiteboards offer these users that convenience. With immersive whiteboards in a networked collaborative environment, the benefits are enhanced. Not only do users share a common environment, they can interact with each other, navigate around the virtual world, exchange ideas on the immersive whiteboards, and share multimedia objects. Some typical applications include virtual conferencing, design collaboration, brainstorm meetings, distance education and Internet learning applications.

Figure 4. An Auction Application Using The Immersive Whiteboard System.

For some applications, the whole collaborative whiteboard session can be recorded and later played back in their dynamic form, allowing users to see how a design was finally generated, and not just the final static image of the whiteboard. Our system allows playback of these sessions in MPEG-4 format. For distance education, the record and playback features are essential for students interested in studying the materials again before an exam.

Figure 4 illustrates an auction application using the immersive whiteboards in a networked collaborative environment. In the scenario, three bidders are interested in a banker's lamp, which is placed on the podium in front of the room. The moderator at the podium is conducting the auction and placing the current highest bids on the whiteboard. The bids are coming in via the specific user's audio channels and the moderator is repeating each bid. Any user in this world can make a bid for this auction by raising his hand and saying his price. Furthermore, there are other auctions concurrently taking place in this large auction house. As a user navigates around the house, other auctions with their respective immersive whiteboards and bidding 3D objects come into view.

8. Summary

In this paper, we presented immersive whiteboards in a networked collaborative environment using the NetICE platform. The immersive whiteboard system consists of five technical components to provide a convenient environment for users at multiple locations to communicate with each other and interact with objects available to them. The five technical components are the following: (1) a network to connect the users, (2) an immersive environment to present each user's participation, (3) an avatar representation for each user as a form of identification and expression, (4) multimedia objects to share with other collaborators or use as a mean of communication, and (5) a shared whiteboard for drawing, pointing, navigating, and displaying in the immersive environment. These components and the physical setup describe how the immersive whiteboard system can benefit several conferencing and collaborative applications.

The setup of the immersive whiteboards is divided into two sections. The first part includes the software and networking system, whose platform is provided by NetICE. The second involves the physical setup, I/O interfaces, and the display. The virtual whiteboard in the immersive environment corresponds to the physical whiteboard in the setup. Including drawing on the shared whiteboard, our setup permits users to control application menus, insert multimedia objects into the world, and navigate around the virtual environment. Furthermore, the networked collaborative environment allows multiple users to share a common world and demonstrate their avatar representation, audio, expression, and interaction.

9. References

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