Applying Videogame Technologies to Video Conferencing Systems

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ABSTRACT

We have developed a desktop meeting environment named FreeWalk that supports casual meetings in a 3-dimensional (3D) virtual shared space, *community common*.

Tools for human communications are always required to run at a practical speed in a widely-used non-luxury hardware environment. However, in the previous researches on 3D conferencing systems, such as VRML-based systems, this aspect has been sometimes neglected. Though we need a research testbed for investigating human-human interactions, researchers tend to concentrate on advanced 3D technologies. In the area of videogames, on the other hand, where 3D virtual spaces are also provided, technologies used there successfully achieve an attractive presentation under severe hardware constraints.

Therefore, in the development of FreeWalk, we have applied videogame technologies especially to friendly interface and efficient visualization, so to realize casual communications in a network.

Keywords: Videogame, Video conference, 3-D space, CSCW.

INTRODUCTION

Recent drastic advances in telecommunication networks have extended groupware systems to support more open organizations [5]. Video conferencing systems used in open organizations can be classified into two categories: business meeting systems and casual meeting systems. Business meetings often utilize the formalized communication channels and protocols among the participants. Casual meetings, on the other hand, are mainly for informal communications, such as chatting in a hallway. Though the tools for casual meetings have been developed, previous research tend to focus on advanced multimedia technologies[1, 4, 11, 12].

We have developed FreeWalk, a system that supports casual meetings in a 3-dimensional (3D) shared virtual space, called *community common* [8, 9]. In this play ground, the live video mapped on the 3D polygons effectively displays the faces of users. Casual meetings are characterized by accidental encounters, unlimited number and types of participants, and unpredictable topics of conversation. Since social interactions in electronic casual meetings have not been investigated, various experiments are needed for further studies. Though several conferencing systems, that use a 3D shared virtual space, have been developed [13, 14], their major concern is to construct a realistic virtual world. As a result, their approaches require a special-purpose or high-performance hardware environment. Though casual meetings play an important role in human activities, it is hard to ask people to use luxury machines in daily life. Our approach in this paper is, therefore, to implement a casual meeting system that runs at a practical speed in a widely-used environment.

There exists another application area that uses virtual 3D spaces, i.e., *videogames*. Some videogames provide multi-user environments where users can control their *characters*. After investigating the similarities and differences between the two areas, we reach to conclude that videogames and video conferencing systems can share enabling technologies. In this paper, we demonstrate that videogame technologies are applicable to design and implement casual meeting systems. We describe how the videogame technologies are adopted in the FreeWalk system. We also show the evaluation results of FreeWalk and the effectiveness of our approach.

WHY VIDEOGAME TECHNOLOGIES

Figure 1 overviews various existing communication tools. The X-axis represents the amount of data transmitted, and the Y-axis represents the computation performed by those tools.

From the view point of transmitted data, those tools can be roughly classified by data types. Since most chat systems or E-mail systems are text-based, their data size is small. On the other hand, video conferencing systems send a large amount of live video and audio data.

The communication tools are also classified by how the transmitted data are presented to users. While E-mail systems do not modify data for presentation, Comic Chat [6], a text-based chat system, generates a comic strip representing the conversation among users. Some of video conferencing systems, like InterSpace [14] and FreeWalk, provide a 3D view of the current meeting status: how many people are in the space, who are talking with each other and so on. From Figure 1, it is clear that video conferencing systems with a 3D shared virtual space are placed at the upper right in the chart. This means video conferencing systems tend to consume both computation power and bandwidth of network. On the current computer technologies, only luxury machines could grant the request.

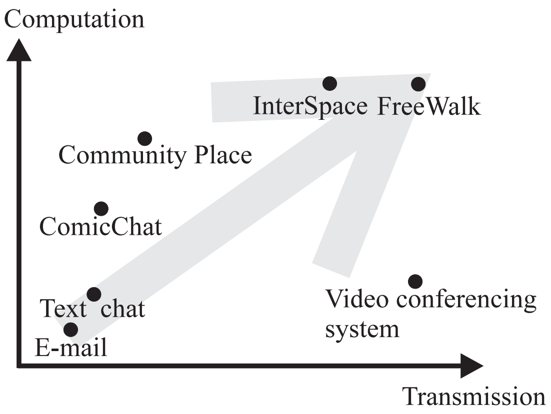

Figure 1: Overview of communication tools.

Several multi-user environments with a shared 3D virtual space have been developed. In the 3D space, users can move their characters and meet with others. For example, Community Place [13] is a text-based chat system implemented with VRML2.0 [2]. InterSpace and FreeWalk require more bandwidth for providing live video and audio channels.

It is worth to point out that videogames also utilize the 3D presentation. Most of them realize virtual spaces so that players can control their characters freely. We believe that the following videogame technologies can be introduced into video conferencing systems.

- Displaying global situations in a 3D space.

  In videogames, since the move of characters is fast, and they are often time-bounded, most of them provide facilities for users to grasp global situations.

- Processing all data in real time.

  The main process loop of videogames consists of checking input data, changing internal states and updating output data. The processing time of this cycle must be small enough to give users the illusion that characters in the virtual space are naturally moving.

- Running on a low cost machines.

  Though some of arcade games need special expensive input devices, most of videogames, especially game machines for home use (known as “nintendo” machines) or personal computers, do not. People can play them only with the low-priced general purpose machines with a joy-pad, joystick, mouse or keyboard. Moreover, most of these devices are the standard attachments to such machines.

Since videogames are mainly for amusement, they must be carefully designed to work in widely used equipments. The advantage of videogame technologies discussed above suggests to apply them to video conferencing systems, especially for generating a 3D space and moves of players’ characters in the space. Thus, we applied the technologies of such as *action, shooting, racing* and *fighting* games to the design and implementation of FreeWalk for realizing casual meetings in a network.

DESIGNING FREEWALK

Basic Concept of FreeWalk

FreeWalk is a desktop conferencing system that supports casual meetings among more than a few users (Figure 2). FreeWalk is the successor of a meeting scheduling system called Socia [16], which introduced non-committed meeting scheduling, wherein the agents do not commit to any plan and thus do not govern their users’ schedule. To realize more flexible encounter, FreeWalk provides a 3D community common where everyone can meet. In this 3D space, each participant is represented by a pyramid of 3D polygons. His/her live video is mapped on one rectangular plane of the pyramid. The participant’s view point is located at the center of this rectangle. The view of the community common from his/her view point is displayed in the FreeWalk window.

Figure 2 shows an example view of a participant. People standing far away appear smaller and those near are larger. People can rearrange their locations freely. Since each participant is represented as an object in the space, the participant can observe the distances/orientations of other people. Figure 3 shows the view changes of participants A and B while participant B rotates.

Participants make a group by standing close to hear the voices and view each other. Since the voice is attenuated through distance, the participant must approach the others in order to talk to them. Therefore, if there is enough distance among groups, the voices of participants in one group are not heard by participants in other groups. This feature makes FreeWalk an effective tool for holding multiple meetings simultaneously in the same space. This limitation forces participants to combine actions and conversations in the space. Each participant can leave the conversation he/she attends just by leaving the group, and can approach another group to join their conversation.

To naturally simulate the users’ real world behavior in a vir-

(a) A's view. (b) The map.

Figure 2: Participant's view of community common.

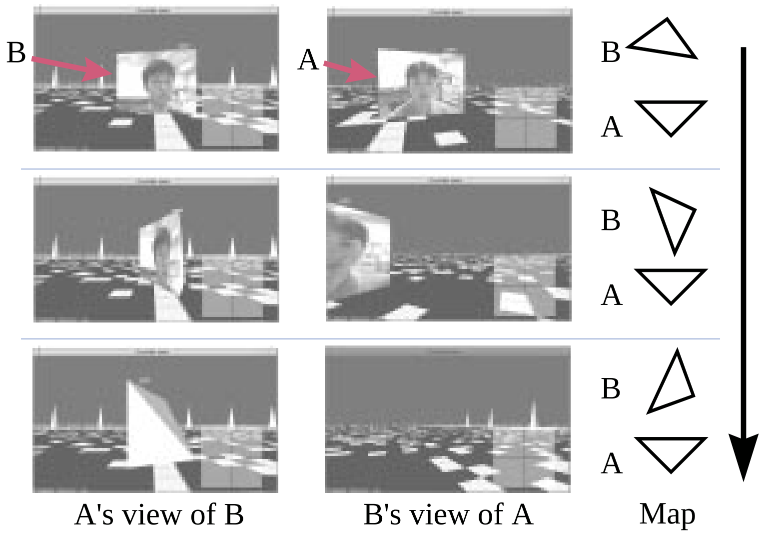

Figure 3: Changes of participants' view.

tual 3D space, it is essential to allow users to move *freely* in the space. The following two sections describe the user interface of FreeWalk, which allows users to move and grasp situations in the 3D space.

Freely Walking in the 3D Space

Since the standard input device for a home game machine is joystick with several buttons, almost all videogames are designed for this device. The motion control of FreeWalk imitates videogames. Since one of the standard device of workstations is a mouse, the motion of users' pyramids is controlled by X and Y valuators of a mouse pointer during its left button is down. The orientation of the pyramid is controlled by the mouse so that the moving/turning speed is proportional to the distance between the mouse pointer and the center of the FreeWalk window. Since users can easily control the speed of moving/turning, they can run when the target is in a distance and slow down as the target becomes closer.

Grasping Situations in the 3D Space

Since the view angle in CRT is much narrower than that of human eyes, it is hard to grasp surrounding situations. Moreover, a human in the real world can easily look around by turning his/her head, but cannot do the same thing in the 3D space. Though virtual reality systems can simulate this by a head-mounted display (HMD), it is not equipped by widely-used machines. In videogames, therefore, additional auxiliary indications and view point switching functions are introduced to help users to grasp their situations. From this observation, we implemented the following functions in FreeWalk.

- Radar Screen:

  A radar-like screen indicates the simplified view of surroundings, including locations and orientations of characters. Figure 4 shows the FreeWalk radar screen. The radar screen can also indicate the volume of people's voice so that user can roughly know the activities in groups.

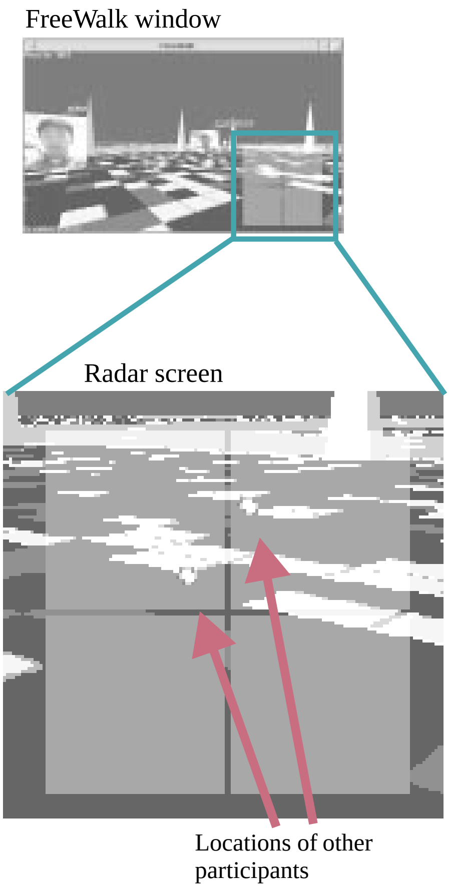

Figure 4: A radar screen.

- View Point Switching

  In some situation, the bird's-eye view is more suitable for grasping the situation. The view point switching function allows users to use multiple viewpoints to select an appropriate view. Figure 5 shows the bird's-eye view from the back of the user's character. This view enables the user to watch both the user's character and his/her surroundings. As a result, the user can have a better view of geometric relations among participants, and thus move easily than using the normal view.

IMPLEMENTING FREEWALK

System Configuration

The FreeWalk system consists of a community server and clients, each of which includes vision and voice processes. Figure 6 illustrates the interaction among the community server and clients. When a user makes a move using his/her mouse, the corresponding client calculates the new location and orientation, and sends them to the community server. The community server then compiles information from all clients with their locations in the 3D community common. The server finally sends the list back to each client for screen updating.

Because not all clients can be seen from every client, it is not necessary for each client to send its live video to all the others. Thus, live video and voice data are sent to each client based on the list of locations received from the community server.

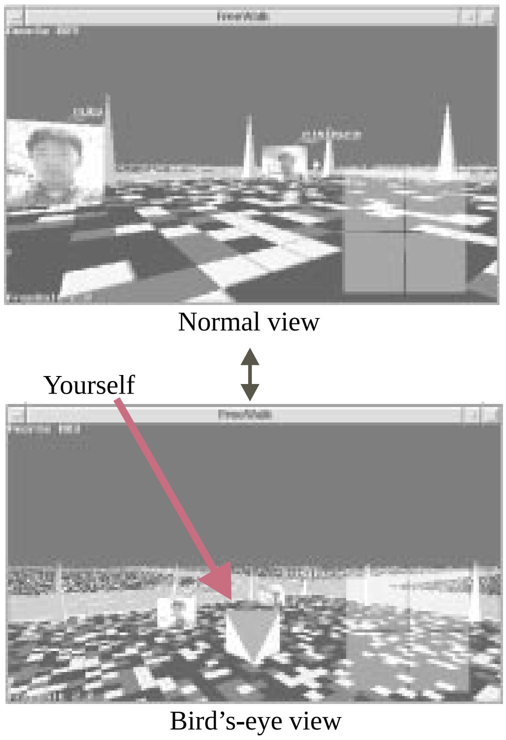

Figure 5: Switched view point.

Drawing the 3D Space

The frame rate for drawing the 3D space determines whether users can move freely or not. From our experiences, to move freely in the 3D space, the fame rate should be at least 8 or 10 frames per second.

One of the most popular methods for constructing 3D space is to combine various polygons. To draw a particular pattern on each polygon, a texture image is usually mapped on its surface. Without special hardware support like a geometry engine processor and a texture engine, however, the above method cannot achieve realtime performance. In videogames, on the other hand, various efficient drawing techniques for 3D spaces are commonly used. We introduced some of those techniques in the implementation of FreeWalk.

For mapping a texture image on the ground of the 3D space, the texture image is first rotated so that the direction of the user's view projected on the ground becomes upward (See Figure 7(a)). We then determine the start point and zooming ratio of every scanning-line according to the angle of depression (See Figure 7(b)). This method is to imitate the perspective representation. Since the method is simple and efficient, it is often used by existing videogames even if the games are targeting a machine with a geometry engine processor.

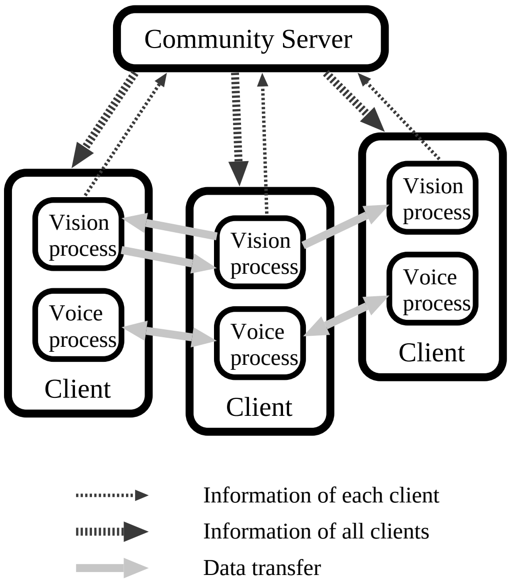

Figure 6: System Configuration

EXPERIMENTS

Evaluation of Videogame Technology

We compared the speed of our drawing routine to OpenGL library, which is now generally used for drawing 3D graphics on workstations and PC. We implemented the OpenGL version of 3D drawings to the 3D space of FreeWalk. The frame rate on R4400 INDY workstation, which has no hardware support for 3D graphics, was 5 frames per second when the size of image was 320×240. On the other hand, the implementation of FreeWalk with our drawing routine achieves the frame rate of 10 frames per second on the same environment in the same size of image.

FreeWalk has been released on the WEB since 1996. Various impressions have been reported from users who experimentally use FreeWalk. Most users felt that its user interface is similar to videogames and enjoyable as if they were playing a videogame. They also reported that the operation of FreeWalk is intuitively understandable, and easier than other video conferencing systems.

Intranet Experiments

We conducted an experiment to verify the implementation of FreeWalk. We first installed FreeWalk into 50 INDYs connected by 10Mbps Ethernet in Tohwa University. Thought the test running was successful, the over concentration of clients caused a network congestion and howling in audio when several participants joined at a time. This was because the initial location in 3D space was fixed.

We then experienced an intranet meeting with FreeWalk in the event called *Open Campus* (the campus were open to public) held in Tohwa University. The visitors of the event joined FreeWalk meetings without any scheduling beforehand. The meeting continued about six hours and a maximum of 13 users participated simultaneously. As a result of investigating the log data, interesting behaviors of users in the virtual space were found as follows.

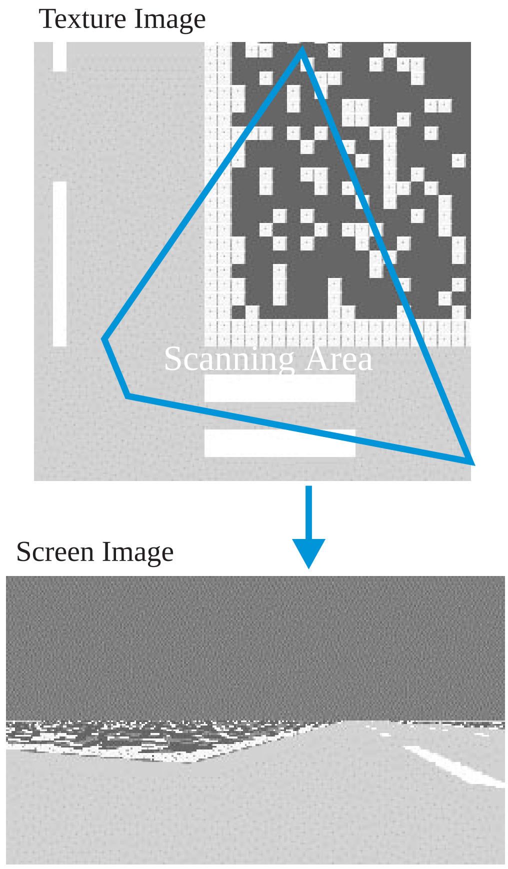

Figure 7: Drawing the 3D space

- Most people move around the center landmark of the space.

  All the participants did not try to go far from the center. As population density around the center became high, network traffic exploded. This is because multimedia data of many participants are transferred to each client though he/she does not talk to most of them.

- A group of people moved together.

  It was often observed that a couple of people moved together to a long distance, but seldom more than three. Some users reported that they wanted to ride a bus, because it is hard to move together.

- Some people wandered from a group to group.

  In the latter half of the meeting, a number of participants who moved around decreased. Moving participants then wander from a group to group. It is very often observed that a couple of people faces each other.

Internet Experiments

We also conducted a preliminary experiment to verify whether our implementation of FreeWalk is competent to communicate through the Internet. In this experiment, four users at Kyoto University in Japan and one user at the University of Michigan in the United States joined the communication server of FreeWalk at Kyoto University.

The frame rate of 3D drawing was about 10 frames per second, the same as in the previous intranet experiments. Though the delay of the live video was longer than that of an intranet, it was inconspicuous and did not affect the control of the player's character much. The users reported they could hold a meeting as good as through an intranet. Sometimes the bandwidth between Japan and the United States forced us to lower the video frame rate to 4 frames per second. However, the users was still able to find others smiling through the live video.

The delay of audio was inconspicuous, too. However, the audio of the user at the United State sometimes became intermittent and the other users were unable to catch what he said while he could clearly hear the voice from Japan. Farther experiments found that the loss of UDP (Internet User Datagram Protocol) packet transmitting audio data caused the intermittent audio.

CONCLUSION

We applied videogame technologies to our desktop meeting environment named FreeWalk that supports casual meetings in a 3D virtual shared space. FreeWalk imitates the user-interface of videogame in controlling the user's character and in grasping the surrounding situation. The technologies enable us to make the system practical enough for the widely used hardware environment.

We also conducted preliminary experiments on our implementation through an intranet and the Internet. From the intranet experiments, we verified that FreeWalk runs at a practical speed with a large number of users. From the Internet experiment, we showed that the implementation enables users to communicate through the Internet.

On the other hand, the technical issue found in the Internet experiments is the intermittent audio caused by the packet loss. The market-base approach to control quality-of-service [15] can be one solution.

The user's behaviors in the intranet experiments suggest us the next stage of FreeWalk. A large scale experiment is also required for further research on casual meetings. FreeWalk can be obtained from
`http://www.lab7.kuis.kyoto-u.ac.jp/`.

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