Development of a Mixed Reality Conferencing System for High Realistic Sensation

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Abstract

Mixed reality has been used as a way to add virtual objects over the physical world. One of the way to realize a distributed meeting with high realistic sensation could be the use of mixed reality. Avatars of distant participants are superimposed over the sight of a local participant. However, it is not very clear about the design of conference avatars. This paper discusses the design of avatars, and describes an experiment on avatar design for distributed mixed reality conferencing system. Regarding the appearance, photo-based body was preferred as natural. The size of avatar that was recognized as life-size was smaller than the actual size.

1. Introduction

Teleworking has been increasing but meetings will never disappear. Thus teleconferencing has been a major topic of IT research[1, 2]. While videoconferencing has been particularly popular in this domain[3, 4], mixed reality has been used as a way to add virtual objects over the physical world[5]. Distributed meetings can be realized with mixed reality technology[6, 7]. In this case, avatars of distant participants are superimposed over the sight of a local participant.

However, it is not obvious how avatars should be presented in mixed reality. The importance of avatar's presentation on 2D display is recognized[8][9], but avatar's presentation of 3D mixed reality is not well known. The design of avatars includes not only the avatar itself but the position of avatars. There are articles about the design of meeting space[10, 11, 12], and the seat arrangement[13, 14, 15, 16]. There are a few distributed 2D conferencing system that considers meeting space such as Hydra[17] and HERMES[18].

This paper discusses the design of avatars, and describes an experiment on avatar design for distributed mixed reality conferencing system. Particularly, we considered the appearance, size, distance and seat arrangement of avatars. A prototype conferencing system that present 3D avatars in the physical world was then developed.

In the next section, design of avatars for mixed reality is discussed. In the section 3, the conferencing system is described. In the section 4, an experiment for design of avatar is presented. The conclusion is given in the section 5.

2. Design of avatar

Because Mixed Reality is a relatively new technology, it has not been exlored enough about the design of avatars.

2.1. Appearance of avatar

Distributed conferencing systems using 3D avatars have been researched[1][19][20]. In FreeWalk[20], the avatar was presented as a square pyramid lying on its side. A motion picture of a participant was displayed on a bottom square of the pyramid. In Virtual Actor[21], the avatar was an upper body presented by CG. These were in virtual reality systems. In high resolution version of the InterSpace[22], a CVE, 2 types of avatars of whole body were compared in conversational setting. One was with realistic CG, and the other was with motion picture head and non-realistic body. As a result of realistic CG, directions of the avatar and its face became

easier to recognize, but difference of a face between the CG and the real person became noticeable when the avatar was close. Because the distance between avatars and a participant is likely to be close, the photo-realistic face would be better for an avatar than CG face.

In a research that evaluated the presentation of avatar in the desktop virtual reality[8], three types of avatars were compared on the condition of standing and sitting. The three types were (1) whole CG body, (2) face by motion picture, body by CG, (3) upper body presented by motion picture, lower body by CG. The results was "(3) was the easiest to communicate with in the sitting condition because the user could not see the avatar's lower body".

Based on these, we conducted an evaluation on the appearance of 3D avatars. Avatars were of upper body beucause they were used sitting fairly close in a meeting. We used two types. one was that the head was a photograph and the body was CG. The other was that both the head and the body were a photograph. The detail is explained in section 4.

2.2. Size of avatar

When avatars are presented by CG, the size of them can be changed freely. Life size video image have been used to obtain a realistic sensation in many traditional videoconferencing systems. A big wall screen is sometimes used to achieve it. There are also a number of researches on the actual size of what size of image is recognized as life size. For example, MAJIC videoconferencing system[3] used a 240cm wide and 120cm high curved screen. 75% life size images were evaluated as good while 200% life size images were not very good in the experiment. Actual life size images were often evaluated as larger than life size, too.

On the other hand, there is research that evaluated the optimal size of the human body on the screen in the visual communication[9]. There were three size conditions (real size, half size, double size) and three observation distance conditions (1m, 2m, 4m) in the experiment. The research tells "The analysis of rating data revealed that the condition of 27 degrees of the visual angle was the most natural" and "The human body should be presented in its actual size". However, the size of avatars was not determined exactly because the experiment has only three size conditions.

And there is research that presented an agent in the real world using HMD[5]. The research tells "A big agent gave users the feeling of pressure because the visual angle of HMD was limited" and "Sizes less than 40cm were liked because the user could see all the body". However, there might be a difference between the preferred size of an avatar used in meetings and the preferred size of an agent used for mediation can be different.

Thus, there is a need to examine how the size of avatars presented by HMD is preferred in meetings. And as the relation of size and distance to avatar in TV conference[9], the sizes preferred at each distance may be different. We considered it in sections 4.

2.3. Distance to avatar

The classification of distance between people was known well as "Proxemics"[23]. According to this study, 120-360cm is the social distance, and this distance is used in a business scene. And 120-210cm is used between colleagues. According to this study, a distance of 120-210cm should be used in our system. In the experiment for the size and the distance of avatars, four distances (120cm, 160cm, 210cm, 360cm) are used.

2.4. Seat arrangement

There are various classification of conference types[10][11][12]. Appropriate seat arrangements are different for each kind of conference.

A facilitator is important for conferences. The roles of a facilitator were known as follows.

1. He makes the meeting progress, and doesn't touch the content.
2. He makes no ideas, and doesn't evaluate the ideas of participants.
3. He makes all members participates, and makes them speak their opinions.
4. He makes no criticism to particular participants.
5. He is perfectly neutral at the meeting.

Form these roles of the facilitator, we need to arrange him in a seat so that he can see all participants.

In this paper, we follow the article [10] in classification of conference types. Article [10] classified four kinds as follows.

Convey meeting Goals of the meeting are conveying information and making participants understand.

Creative meeting Goals of the meeting are analyzing matters and solving problems.

coordination meeting Goals of the meeting are checking activities of each department and discovering overlap.

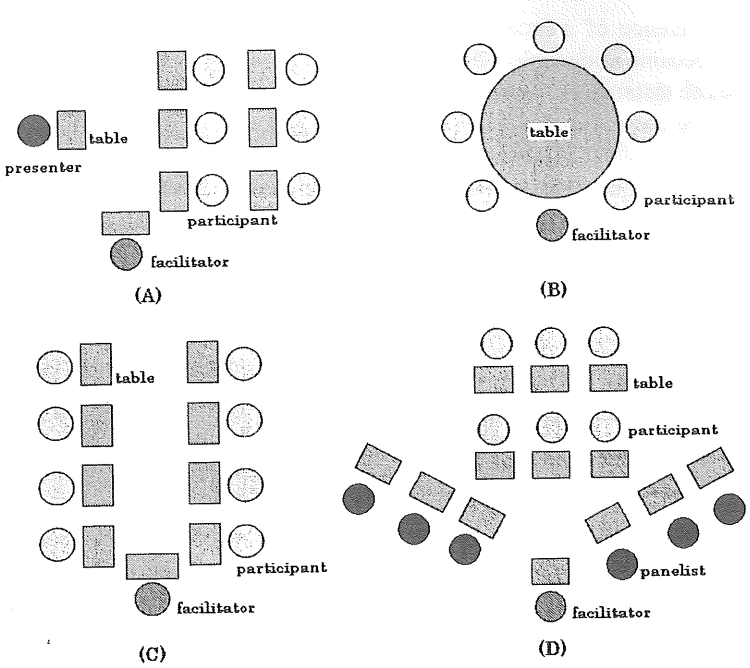

Figure 1. 4 patterns of placement

Decision meeting Goals of the meeting are deciding intentions and activities of a company.

We made four patterns of seat arrangement for meetings (Figure1).

It is important to convey information from a presenter to participants at a Convey meeting. So one presenter opposite to participants as in seat arrangement (A) in figure 1. The facilitator forms a right angle to the presenter and the participants.

It is important to make various ideas freely at a Creative meeting. To make an atmosphere that enables participants to make idea easily, they must sit around a round table as in seat arrangement (B).

Coordination meeting is close to a Creative meeting, in that all participants discuss one theme. So the Coordination meeting's seat arrangement should be (B). However, in the case of each department conveying information to another, seat arrangement (A) is better than seat arrangement (B).

Decision meeting is used in various scenes. In the case of that, all participants discuss one theme and they have the same rank, seat arrangement (B) is the best. And in case of a debate as two groups discuss a theme to reach a conclusion, it is necessary to distinguish between two groups as in seat arrangement (C). Lastly, In case of panel discussion as that, participants take part in the meeting after panelists' discussion, seat arrangement (D) is the best. In seat arrangement (D), there is a difference between panelists and participants, and make facilitator be able to see all participants.

3. MR conferencing system

We implemented a prototype system for meeting. We refer to the implementation in the following.

3.1. Hardware

Our system is mainly based on Canon's MR Platform system[24], which includes a video see-through head mounted display. We also used the Polhemus's Fastrak, six degree-of-freedom (DOF) electromagnetic tracking sensor, and a Red Hat Linux 9.0 PC (2.80GHz Pentium4 CPU, 1024MB RAM, nVIDIA GeForce FX5950 Ultra GPU).

3.2. System architecture

Figure2 shows the schematic diagram of the prototype system, and Figure3 shows the overview of the system.

There are four participants at each point in figure2. User equips with a HMD. Other participants take part in the meeting at a sound isolated room. User cannot directly see remote participants and cannot hear the voice of remote participants. And, video and voice are conveyed not via network but a direct cord.

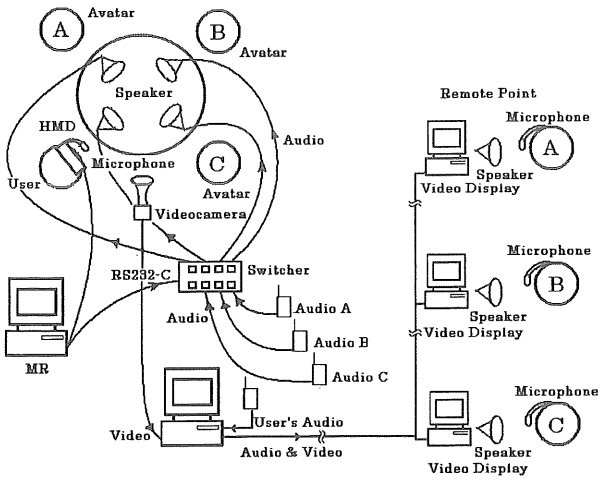

Figure 2. Schematic diagram of the system

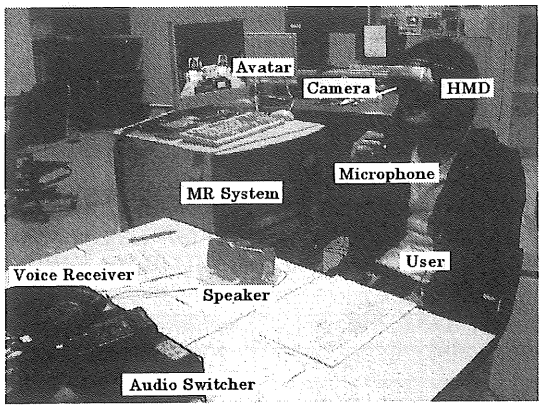

Figure 3. The system overview

Voice management The voice of the user is conveyed to the remote point via a wireless microphone. The voice of remote participants is conveyed to a matrix voice switcher via a wireless microphone receiver. Because the voice switcher is connected to the MR Platform system by RS232-C, the system can manage input and output via a serial connection. Speakers are set at all seats in the meeting room. Thus the voice of remote participants output from a speaker in front of his avatar by serial connection.

Video management Remote participants are presented as avatar in the real world. User can see it via his HMD. The video of the appearance of the meeting room is send to remote point. Remote participants can see it via a PC display.

Seat arrangement of avatars Users must input the number of avatars, the ID each member and which seat arrangement from (A) to (D) in figure 1. Because the HMD has a magnetic sensor, the system can obtain the positional information. From the information, systems specify the user's seat and present avatar at empty seats.

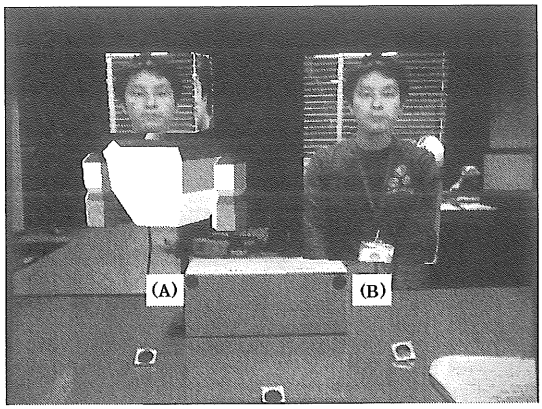

Figure 4. Subject's view for avatar appearance evaluation

4. Evaluation of avatar design

4.1. Appearance of avatar

We experimented how appearance of avatar is preffered when the avatar is presented by HMD. Subjects consisted 20 of university students and graduate students. And we examined two types of avatar as follows.

A. Head presented by real picture, and the body presented by CG.

B. Head and body presented by a real picture.

Subjects were presented with the two types of avatar at 160cm in front. And they selected which avatar was more natural. Figure 4 is the view of the subjects when they choose the preferred avatar design.

In this result, 18 subjects chose (B). The reasons why 18 subjects chose (B) were "Because (A)'s body was unnatural" and "Because the joining between the head and the body of (B) was more natural than (A)". And the reasons why 2 subjects chose (A) were "Because avatar (B) looks like a 2D picture and (A) looks like 3D" and "Because the needless back ground of (A) was less than (B)".

It most be considered that these results may change in case of improvements to the quality of the CG models.

4.2. Size and distance of avatar

4.2.1. Purpose of experiment. There has been a lot of research which has examined the natural size of a person on a PC display or big screen. However, the amount of research for see-through HMD is small. We experimented how size of avatar is felt natural when the avatar is presented by a HMD.

4.2.2. Method of experiment. Subjects were presented with 8 conditions using two display media (HMD and 2D display) and four observation distances (120cm, 160cm, 210cm and 360cm). Subjects were the same 20 used in the experiment in section 4.1. We used a PDP-504CMX on Pioneer as 2D display. It isn't inferior to HMD in respect to display quality because its display is 983 thousands (1280 by 768) pixels.

Display size of an avatar starts from 70% or 130% of real size. They are displayed by HMD or 2D display. So there are four conditions. Five subjects each were assigned to each condition for balance(1). The four observation distances were set at random.

Figure 5 shows the views of the subjects. The top figure is the view by HMD, and the bottom figure is the view by 2D display. These are the views in the case of the distance to the avatar being 160cm, and real in size. And these avatars's height was adapted to realistic height.

4.2.3. Result of experiment. We explored the average size which subjects recognize as real size for each distance. And we carried out the Willcoxon-Mann-Whitney Test to the data. The result is shown in table 2.

Average sizes using HMD where distances were 120cm or 160cm or 210cm, were about 86% of the real size. The sizes using 2D display were about 90%. Subjects using HMD at these distances felt avatars larger than in the case of using 2D display. There was a clearly difference between results at 120cm using these two media from the Willcoxon-Mann-Whitney Test. The results at 210cm has some difference. At relatively short distances, people using HMD feel avatar larger than in the case of using 2D display. Thus people feel pressure from avatar because the visual angles of our system's HMD covers only 51 degrees.

On the other hand, the average size using HMD at 360cm was about 95% of the real size. This is larger than the result of using a 2D display. Subjects using HMD in this distance felt the avatar smaller than in the case of using a 2D display. There was some difference between the results. Probably, the reason why people feel that was because of the reduced pressure of the avatar. The farther away the avatar presented, the less pressure people feel.

Table 1. Subjects assignment

	from 70%	from 130%
HMD → 2DD	5	5
2DD → HMD	5	5

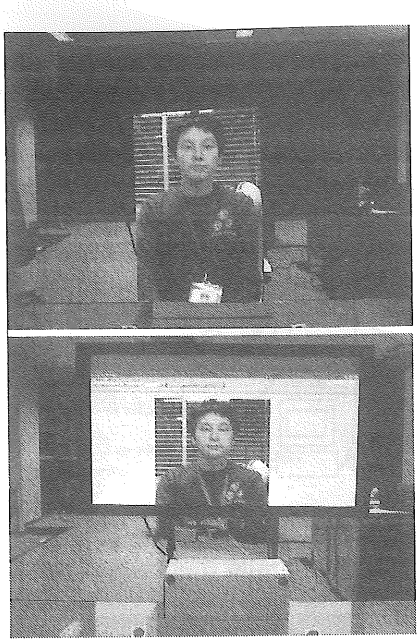

Figure 5. Top: Subject's view by HMD; Bottom: Subject's view by 2D display;

Table 2. Results of life-size avatar evaluation

distance to avatar (cm)	life-size in 2D display (%)	life-size in HMD (%)	p value in Wilcoxon Test
120	92.0	86.3	**0.015
160	89.0	85.6	0.110
210	89.2	85.7	*0.096
360	91.1	94.9	*0.079

(N=20; **:$p < 0.5$, *:$p < 0.10$)

5. Conclusion

This paper describes an experimental design of avatars for mixed reality conferencing system. In the results regarding appearance, the avatar presented by a real picture was the most natural. And in the results regarding size, about 86 % of actual size was recognized as real size when the avatar was shown at 120cm, 160cm and 210cm in front. These avatars were perceived larger

than in the case of using a 2D display. Similarly, about 95% of actual size was recognized as real size when the avatar shown 360cm in front. This avatar was recognized as smaller than in the case of using a 2D display.

We implemented the prototype systems to present avatars in the real world for distributed meetings. We must evaluate this system in the future work. We expect that the system will provide user with high realistic sensation rather than a traditional meeting system using 2D display.

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