MAJIC Videoconferencing System: Experiments, Evaluation and Improvement

Yusuke Ichikawa, Ken-ichi Okada, Giseok Jeong, Shunsuke Tanaka
and Yutaka Matsushita
Department of Instrumentation Engineering, Keio University
3-14-1 Hiyoshi, Kouhoku-ku, Yokohama, 223 Japan
Tel: +81-45-563-1141, Fax: +81-45-562-7625
E-mail: ichikawa@myo.inst.keio.ac.jp

We need to know the real intentions of participants that are not expressed by verbal languages
This means that not only verbal information but also non-verbal information (i e , gestures, facial
expression, eyes of participant, etc.) is a very important factor We proposed and implemented
MAJIC, a multi-party videoconferencing system that enables eye contact among people in remote
places, with life-sized images of participants

In order to evaluate users' perceptions of MAJIC, we have experimented with the size, back-
ground and boundary of the video images. These experiments verify the sense of presence in
MAJIC environments where life-size video images without boundaries are supported We devel-
oped a new MAJIC prototype based on these experiments

Introduction

Face-to-face meetings are the best way to make decisions, but it is sometimes
difficult to assemble participants at the same time and same place. There
have been many studies on tele-communication support systems using video
images [6, 7, 8], and we think video-conferencing systems could be developed
in two categories. One attaches importance to portability, in order to be able
to communicate with anyone, anytime and anyplace. An example of this is

desktop conferencing systems [9, 10, 11]. We will be able to have meetings using multi-media notebook computers equipped with radio network facilities in the near future.

The other category attaches importance to reality, and, as a result, usually requires a large space. Some topics or keywords in studies of these systems are

(1) informal communication support [12, 13, 14],

(2) simulation of a multi-person round-table meeting [4, 15],

(3) eye contact support [3, 16],

(4) integration of communication space and work space [3, 17] and

(5) virtual reality [18].

In order to communicate with each other by videoconferencing with a sense of presence, one of the most important problems is how to support eye contact among participants and provide life-size portraits of them. Many systems use a half transparent mirror to support eye contact, while other systems use a large screen to provide life-size portraits, but it is difficult to provide both. Moreover, in the case of multi-party videoconferencing, multiple eye contact should be supported, and to support a sense of presence or feeling of togetherness, there should be no boundaries between the pictures.

In face-to-face meetings, we need to know the real intention of participants that are not expressed by verbal languages. This means that not only verbal information but also non-verbal information (i.e., gestures, facial expression, gaze of participant, etc.) is very important factor.

As the proverb says, "The eyes are more eloquent than the tongue." In many cases, we perceive one's true intention from his/her facial expressions and gestures. Moreover, the gaze serves to regulate the flow of conversation. Therefore, it is important for telecommunication systems to establish a method to enable non-verbal communication, such as communication made by facial expressions and gestures, as well as verbal communication. However, since cameras are mounted above display devices in conventional videophones or teleconferencing systems, natural communication with eye contact could not be achieved We have developed a multi-party videoconferencing system, MAJIC, which supports teleconferencing with a sense of presence [1, 2].

The design of MAJIC

The MAJIC system has three concepts. The design concepts are:

Life-size portrait and background without boundaries

There are two important factors in achieving a sense of presence during video-conferencing. One is the size of participants' images on the screen. For example, we may feel participants are far away if their portraits are smaller than life-size. Moreover, it would be difficult to read facial expressions or gestures if participants are shown on a small display or displays. Another factor is the background behind the portraits. Although there are some systems that use multiple displays to provide for multi-party conferencing, to achieve a feeling of togetherness, there should be no boundaries between the portraits. If users are surrounded by other participants with a seamless background, they can feel as though they are together.

Multiple eye contact and gaze awareness

Multiple eye contact among participants should be supported to make multi-party conferencing effective since without eye contact or calling out the person's name it is difficult to speak to a specific participant in a multi-party environment. We usually become aware of one participant gazing toward another through eye movements and head turns in face-to-face meetings. With the Hydra system, it has been reported that movements in the periphery on the screen do not attract recipients' attention because of the problem of small screens [4]. Life-size portraits arranged around a table produce a situation in which the eye movements and head turns of the users attract the attention of the recipients.

Shared and personal workspace between participants

In face-to-face meetings, participants usually sit around a table on which material is piled up in front of them; some material is for individual participants and other material is shared. Of course eye contact is very important in communicating with one another, as mentioned above, but especially in Japan it is impolite to look into someone's eyes for a long time. What should we look at? Sometimes we look at other participants one after another, or we look at the material on the table. A space in front of participants provides each person with a personal workspace and a shared workspace on which to place material; at the same time, it gives participants a reason for averting their eyes.

Implementation of prototype MAJIC

The key feature of the MAJIC system is a screen composed of printed dots on a transparent sheet. The screen looks like a white screen from one side, but a transparent film from the other side. Therefore by setting the camera on the transparent side of the screen (i.e. behind the projected images), it is possible to achieve natural eye contact (Figure 1).
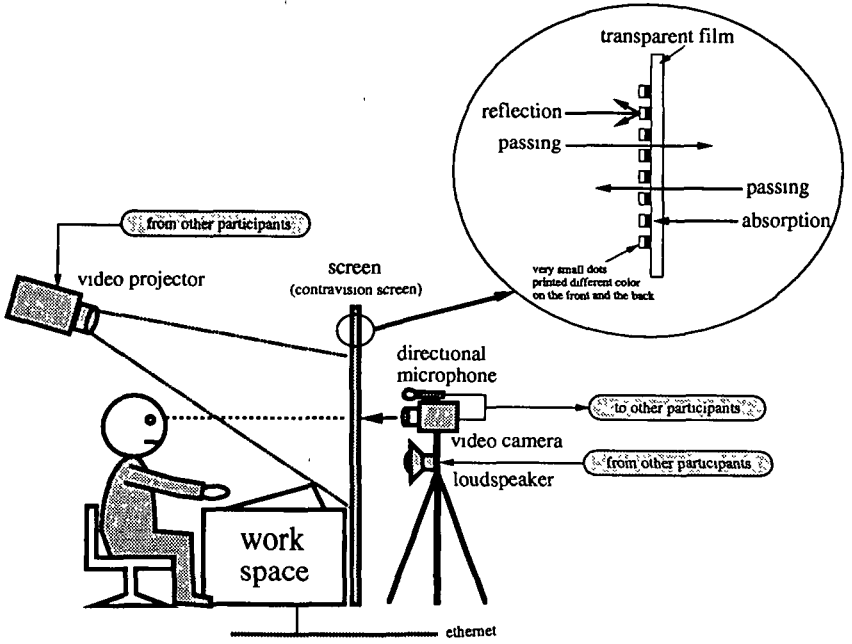
transparent film

reflection

passing

passing

absorption

very small dots
printed different color
on the front and the back

from other participants

video projector

screen
(contravision screen)

directional
microphone

to other participants

video camera

from other participants

loudspeaker

work
space

ethernet

Figure 1. How to support eye contact

to user C

screen

to user B

video camera C

video camera B

user A

video projector B
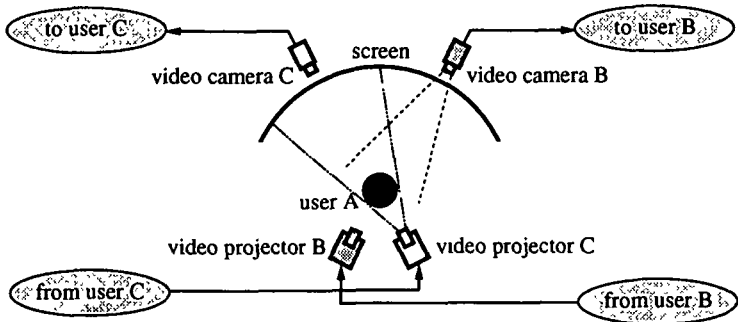
video projector C

from user C

from user B

Figure 2. System constituents of MAJIC

Figure 2 illustrates three-way videoconferencing using MAJIC. When user A turns his head to the right to look straight at user B, user B sees user A full-face and user C sees the left profile of user A. In other words, user C becomes aware of user A gazing toward user B, and user B becomes aware of the head-turning of user A toward him/her and can make eye contact with user A if he/she likes. Thus the MAJIC system supports multiple eye contact and gaze awareness.

When user A sits at the center of the arc, the distance between user A and users B and C is around 4 feet. Distances between people vary according to their relationships and are classified as follows [5]:

(1) Intimate distance: 0 – 45 cm

(2) Personal distance: 45 – 120 cm

(3) Social distance: 120 – 360 cm

(4) Public distance: more than 360 cm

We have concluded that around 120 cm may be the best distance for face-to-face meetings with 3 or 4 colleagues, since the distance from people who work together tends to be shorter at a social distance, or it is sometimes than a personal distance.

Figure 3 shows multi-party videoconferencing using MAJIC.

Experiment using MAJIC

We have conducted experiments to explore the effects on to participants of various factors of the projected image (i.e., the size of participants' images, background and seams between images) using the MAJIC prototype. The data of this experiment were analyzed by factor analysis, and we improved MAJIC based on the results.

Method

Subjects

40 students in engineering participated: 10 women and 30 men.

Experimental Conditions and Apparatus

Subjects saw participants in experimental video conferencing in six conditions as follows. Condition 1 is basic MAJIC environment; that is, life size participants' images, with the same background behind other participants and seamless between images. In condition 2, the backgrounds of the participants were different; other factors were the same as in condition 1. There is a seam between images in condition 3. Large participants' images (twice as large as

Figure 3. MAJIC in use

condition 1) were projected in condition 4; small images (.75 times) were projected in condition 5. Two small displays were used in condition 6 Hence, there were very small participants' images and a seam between them in condition 6.

	size of images	background	seams between images	apparatus
1	life size	same	seamless	MAJIC screen
2	life size	different	seamless	MAJIC screen
3	life size	same	10cm	MAJIC screen
4	large (×2)	same	seamless	MAJIC screen
5	small (×.75)	same	seamless	MAJIC screen
6	very small (×.3)	same	100cm	Using 14 inch display

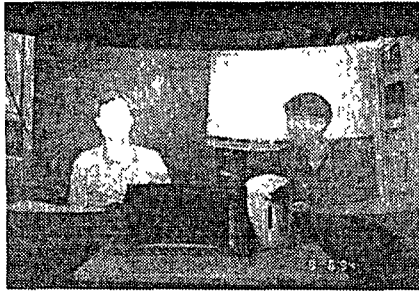Table I. Experimental conditions and apparatus

Procedure

Each subject watched a video conferencing movie filmed beforehand in each condition. The movie shows typical usual informal conversation (the participants in the movie sometimes speak to the subject). One minute later, subjects were asked to respond to 16 questions about the condition which they had just
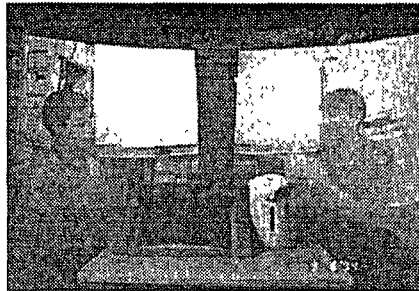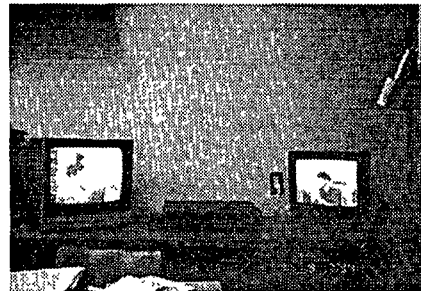
Condition 1

Condition 4

Condition 2

Condition 5

Condition 3

Condition 6

Figure 4. Experimental conditions

experienced. The questions concern sense of reality, virtual distance, gaze awareness and atmosphere. A score of 7 represents "Strongly Agree", while a score of 1 represents "Strongly Disagree". A score of 4 represents "Equal" for questions concerning distance; that is, Q2, Q7 and Q11. The questions are as follows.

Q1. I was able to understand what other participants did.

Q2. I felt other participants were larger than life size.

Q3. It's not unnatural when other participants "shook hands" or "linked arms."

Q4. I felt as though they were together.

Q5. The conversation was natural.

Q6. When I looked at other participants at the same time, I had a sense of congruity.

Q7. I felt participants were far/near.

Q8. When I moved my gaze from one image to the other image, I didn't feel unnaturalness.

Q9. It seemed other participants were able to communicate naturally.

Q10. I was able to recognize other participants' gaze.

Q11. I wanted to be farther/nearer to the images.

Q12. I could converse naturally, if there were pictures with a seam.

Q13. I was able to read the facial expressions of the participants.

Q14. The other participants seemed to be in the same room.

Q15. The conversation seemed highly interactive.

Q16. The atmosphere was impressive.

Factor analyses

The mean scores from the questionnaires averaged across 40 subjects are shown in Table II. But three questions concerning virtual distance were excepted, because these questions use different criterion. We discuss virtual distance later.

The data are analyzed by a principal components transformation method

	Condition1	Condition2	Condition3	Condition4	Condition5	Condition6
Q.1	6.45000	6.22500	6.00000	4.30000	6.35000	5.50000
Q.2	4.77500	4.90000	4.37500	6.92500	3.22500	1.87500
Q.3	5.25000	3 70000	4.37500	3.20000	5.60000	2.30000
Q.4	4.97500	3.27500	4.20000	3.47500	4.67500	2.65000
Q.5	5.72500	5.62500	5.17500	4.12500	5.92500	4.05000
Q.6	5.87500	4.10000	4.52500	3.72500	6.15000	2.50000
Q.7	3.97500	4.27500	3.92500	5.87500	3.05000	1.92500
Q.8	5.60000	4.37500	4.55000	4.65000	6.05000	2.50000
Q.9	6.15000	5.65000	5.65000	5.12500	6.27500	4.85000
Q.10	6.00000	5.37500	5.75000	4.95000	6.00000	4.45000
Q.11	3.85000	3.87500	3.77500	1.80000	4.65000	3.92500
Q.12	3.97500	3.97500	4.10000	4.15000	4.45000	2.75000
Q.13	6.22500	5.77500	5.90000	6.40000	5.95000	5.35000
Q.14	6.15000	2.87500	4.57500	4.27500	6.05000	3.62500
Q.15	5.87500	5.30000	5.65000	4.72500	6.00000	4.37500
Q.16	4.97500	4.90000	5.02500	5.30000	5.25000	3.62500

Table II. The mean scores from the questionnaire averaged across 40 subjects

using correlation coefficients which were calculated from Table II. As a results, two factors could explain 88.9% of all distributions. After Varimax rotation to these two factors is done [19], the model obtained is as follows:

$$\text{Condition1} : X_1 = 0.298F_1 + 0.934F_2$$
$$\text{Condition2} : X_2 = 0.845F_1 + 0.318F_2$$
$$\text{Condition3} : X_3 = 0.834F_1 + 0.516F_2$$
$$\text{Condition4} : X_4 = 0.864F_1 + 0.042F_2$$
$$\text{Condition5} : X_5 = 0.210F_1 + 0.951F_2$$
$$\text{Condition6} : X_6 = 0.852F_1 + 0.415F_2$$

Discussion

The first factor, F1, has high values when there are different backgrounds, a seam between images, or very large or small images. F1 has been named the "Sense of Incongruity" factor.

The second factor, F2, has high scores in condition 1 and condition 5. With a seamless display between participants, the same background, and a life sized image or a small image, the value F2 is. F2 has been named the "Sense of Presence" factor.

In summary:

- F1: The factor of the Sense of Incongruity.

- F2: The factor of the Sense of Presence.

These factors resulted in two clusters on the plot (Figure 5).
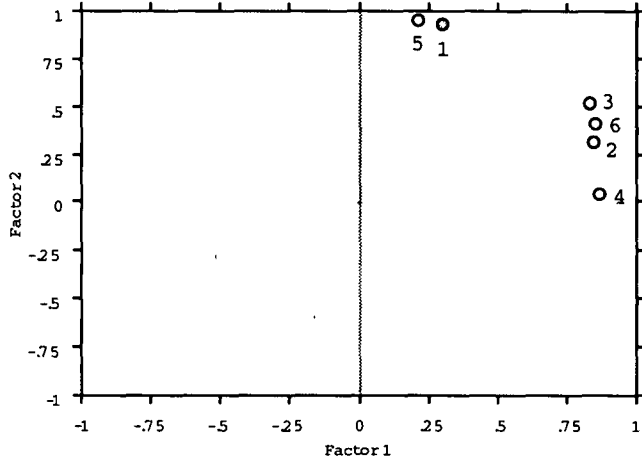

Figure 5 Factor Plot. (Condition 1 is the basic MAJIC environment.)

We diagrammatically depict the results from the questionnaire about the sense of virtual distance in Figure 6. Many participants felt that images are larger than their real size even though life sized images are projected. Therefore,we may say that it is effective to project the perceived image rather than a life sized image.
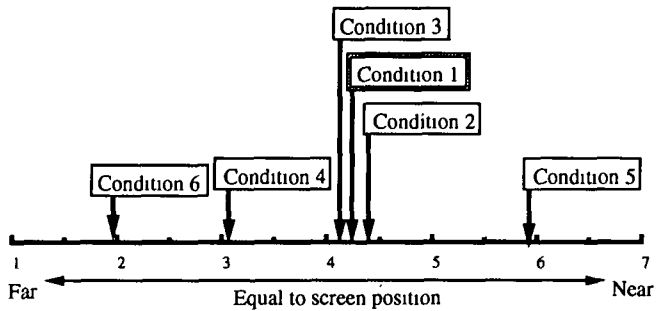

Figure 6. virtual distance

The improvement of MAJIC

The prototype of MAJIC has the following shortcomings:

(1) Only one user at each site can make eye contact with participants.

(2) Users cannot move around.

(3) The number of sites is limited, four-way video conferencing being the maximum possible with the prototype.

(4) The quality of images is not very good.

(5) The size of the prototype is very large.

(6) There is no seam between pictures, but there is a seam between backgrounds.

To overcome some of the problems of the MAJIC, we have improved the MAJIC system based on the conclusions of the experiments.

Miniaturization

The size of the prototype is very large. But from the experimant, it can be said that the sensed distance between a user and other participants is effectal by the projected image size. Therefore, it the user sits closer to the screen on which a small size video image is projected, the size of MAJIC can be miniaturized (Figure 7).

Seamless backgrounds by chromakey

The background influences the sense of presence. The improved MAJIC supports seamless backgrounds by chromakey. Figure 8 shows an example of seamless backgrounds. It will be interesting to observe virtual meetings in various backgrounds For example, what is the effect of the background, or what kind of background relaxes users or inspires them?

Conclusion

We have explored the effects of the size of participants' images, the backgrounds of portraits and the seams between images on the sense of presence. We found that the sense of incongruity is increased by seams between images, differences in background, and unnatural size of participants' images. On the other hand, life size and slightly smaller images produce a sense of reality. From the results, we improved MAJIC by miniaturizing and providing the same background by chromakey.

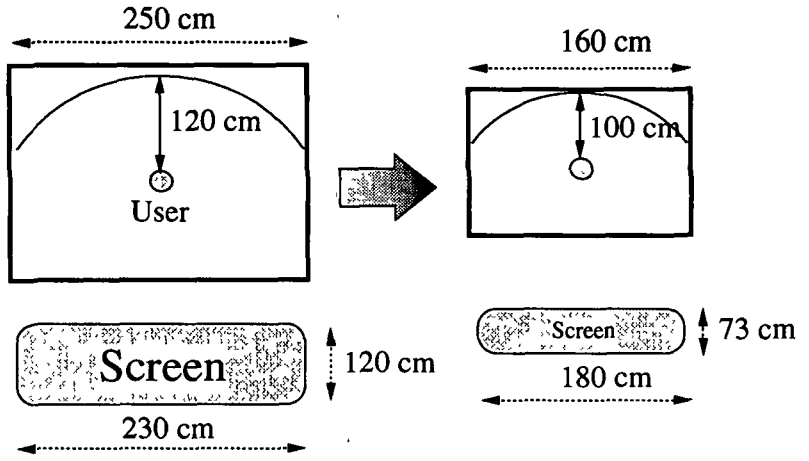We are designing "MAJIC-2" to offer several new functions:
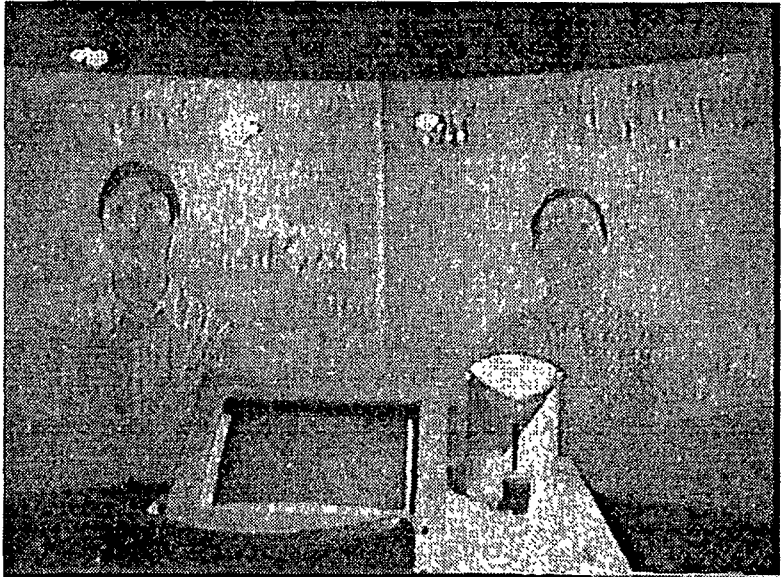
Figure 7. Miniaturization

Figure 8. Seamless background

(1) Support whispering. In a meeting we often speak to only one person. Hence, we design a tool by which participants can whisper. In order to provide this function some switches are attached to the inside of the chair, and switch whispering mode with the motion of a user. This chair is called "Whisper Chair".

(2) A video camera that pursues a person. MAJIC users cannot move around. This limitation is caused by the video cameras set behind the screen. They are mounted on a tripod and fixed on their target; that is, a user sitting at the center of the arc of the screen. In order to overcome this limitations, we introduce a video camera that pursues a person.

We currently have such a system in place and are running a second study to test these functions. We expect our approach will provide the next generation of teleconferencing system.

Acknowledgments

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